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Dependence on Russian Resources and Exchange Rate Fluctuations During the Russia-Ukraine Conflict

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Abstract: This article aims to explore the role played by dependence on Russian resources on the exchange rate of non-belligerent economies, following the Russia-Ukraine conflict. A mixed effect model, which considers both the long-term impact of the conflict itself and the influence of significant sub-events during the conflict, is established to derive the impact pattern of dependency on Russian petroleum, gas, and cereal on exchange rate fluctuations. The model results indicate that dependence on Russian petroleum and natural gas does not have a significant impact on exchange rate fluctuations in the long term, but it is related to a significant depreciation on the dates of conflict-escalating events and economic sanctions. On the other hand, high dependence on Russian cereals is significantly associated with long-term currency depreciation.

Keywords: Russia-Ukraine Conflict, exchange rate, exchange rate fluctuation, resource dependence

1. Introduction

On February 24, 2022, Russia announced the initiation of a "special military operation," deploying its ground forces extensively into Ukrainian territory (excluding the Crimea region), marking the onset of the Russia-Ukraine conflict. Taking into account the political standing, economic size, military power, position in international resource trade of the two conflicting sides (especially Russia), and the significant involvement of major economies indirectly entangled in the conflict, it can be inferred that the economic impact of this conflict would not be limited to the countries directly participated (Mbah & Wasum , 2022).

As an important economic indicator, currency exchange rate not only reflects the current status of an economy and the international market's future expectations for it, but also has an impact on a country's trade (Campa, 2004) and economic development (Rodrick, 2008), making it a highly suitable and worthwhile subject for research.

While this conflict has had a global economic impact, it is evident that the effects (including effect on exchange rate) are unlikely to be uniform across different countries and regions. Instead, they are influenced by each economy's economic foundation and its ties to the warring parties. Leveraging its vast territory, Russia has consistently been a powerful producer and exporter of resources, which is also the major pillar of its position in the international trade system. Russia's position in the resource sector is so crucial that it has long been referred to as an "energy superpower" (Rutland, 2008). In 2021, prior to the outbreak of the conflict, Russia's exports of petroleum accounted for approximately 13% of the world's total exports, natural gas accounted for about 17%, and cereal accounted for approximately 4%.[1] For some economies geographically close to Russia, they easily develop a dependency on Russian exports of resources. For example, in 2021, 23% of the Eurozone's petroleum imports and 26% of its natural gas imports came from Russia. Poland (58%; 57%), Bulgaria (61%; 70%), Romania (79%; 52%), and other countries exhibit even higher dependencies on Russian energy resources. On the other hand, countries such as Turkey (58%) and Egypt (21%) heavily rely on Russia's exports of cereal.[2] European scholars (Cohen, 2007 ; Rutland, 2008) and politicians had been warning long time before the outbreak of Ukraine-conflict that trade impediments with Russia might arise due to military reasons or economic sanctions, and the dependence on Russian resources could lead to catastrophic consequences. After the outbreak of the

[1,2] Data sourced from UN Comtrade.

conflict, these concerns are very likely to have turned into reality. Liadze et al.'s research (2022) indicates that Europe, which relies on energy and food supplies from the warring countries, is the region most severely affected by the conflict's economic impact. Compared to other regions in the world, European economies experience more significant GDP contraction and inflation due to the conflict.

The primary objective here is to determine the depreciation or appreciation impact of dependence on Russian resources on exchange rate changes (against USD) from the outbreak of the conflict to December 1, 2023. The reason for choosing the US dollar as the unified exchange rate standard is because：

a) The United States is the world's largest economy, and the US dollar holds a dominant position in the international currency market. For all economies, the exchange rate against the US dollar is one of the most important exchange rate indicators. To some extent, fluctuations in the exchange rate against US dollar can partially reflect changes in a currency relative to global currencies.

b) In this conflict, despite active participation and even leadership by the United States in providing assistance to Ukraine and imposing sanctions on Russia, the impact of the conflict on the United States is relatively minor, considering both physical distance and economic trade interactions.

c) The US dollar is considered to have safe-haven properties, as evidenced by its appreciation even during crises such as the 2008 financial crisis centered around the United States (Fratzscher, 2009). Therefore, if a currency is found to remain strong against the US dollar during a conflict, it can indicate that the economy is less affected by the conflict or is perceived as better equipped to handle the adverse effects of the conflict. On the other hand, currencies that significantly depreciate against the US dollar are more likely to have been impacted to a greater extent and are viewed unfavorably by the market.

When studying the impact of conflicts on exchange rates, it is important to note that this impact is neither uniform in terms of economies nor in terms of time.

Firstly, as mentioned earlier, the effects on exchange rates are influenced by each economy's economic foundation and its ties to the warring parties. Due to the numerous factors that collectively influence exchange rates, it is challenging to directly ascertain the impact of a conflict on exchange rates. Nevertheless, generally speaking, if a conflict leads to a significant deterioration in the economic situation of an economy or brings about noticeable economic, political, or military risks, then a substantial currency depreciation is likely to occur. Conversely, if an economy is less affected in a globally impactful conflict or if its own economic and financial conditions are healthy enough to withstand risks effectively, then the currency may remain strong.

The factor of concern, dependency on Russian resources, is one of the reasons for the varying impacts on different economies. The potential channels of impact include, as will be mentioned shortly in the literature review section, altering the prices and geopolitical risk of an economy, thereby affecting exchange rates.

For other potential influencing factors that may cause such differences, they must be controlled for in the model. This includes internal macroeconomic fundamentals, which to some extent determine the economy's ability to respond to international event shocks in terms of economics and currency, and also might influence exchange rates even when the impact of events is excluded. Additionally, there's external exposure to the conflict, which directly reflects the magnitude of the impact on the economy (Fratzscher, 2009). The specific choice of controlled variables and the rationale behind their selection will be elaborated in the Data section.

On the other hand, variations over time are even more subtle. What can be evidenced by data is that, for this ongoing conflict, neither military progress (such as changes in battle lines or casualties), public attention (which can be reflected in search indices), nor the resulting changes in trade, prices, etc., develop uniformly or linearly over time. Thus, I believe it can be inferred that, the impact, just like the development of the conflict itself, is not only uneven over time, but also non-linear and cannot be represented by a function of time. It also doesn't have a primary indicator, like the number of infections in the case of events such as the COVID-19 pandemic, that can be used for measurement. In this conflict, the military front-line advances and retreats, with significant differences in military value between important cities and transportation hubs compared to ordinary villages and roads. Economic sanctions and directives are not all issued on the first day of the conflict but are announced and implemented one by one. Therefore, the market does not receive related information at the same frequency and intensity. When relatively significant events occur, there is more reporting, and both the public and the market pay more attention. Therefore, in the research process, it is necessary to simultaneously consider the overall impact of the conflict as an "event" throughout the entire period after its occurrence, as well as the impact of specific "sub-events" during crucial periods within the conflict.

In this study, I chose to focus more on the dates of significant sub-events while also considering the overall impact of the conflict. The reason is that, in the long run, factors affecting exchange rate fluctuations are too complex. These factors include conflict-related elements mentioned earlier, unrelated economic changes and domestic and international news (such as the Fed's interest rate hikes), as well as lagged effects of conflict-related events, making it difficult to accurately capture the role played by Russia's resource dependency in these dynamics using models. However, if we consider the overall impact of the conflict as the background and focus more on the dates of sub-events, factors related to the conflict are more likely to dominate in exchange rate changes. On one hand, it's because, on dates like this, the currency market tends to pay more attention to this conflict compared to other information, and governments or central banks cannot make buffering reactions in such a short time. On the other hand, when the attention is narrowed down to a day, the probability of other significant events occurring or noticeable changes happening at the macroeconomic level relatively decreases.

The practical significance of this study is evident. For currency investors, dependence of an economy on resources from other countries is easily accessible objective data. The conclusions of this study can assist them in incorporating resource dependency into their considerations of currency trends, regardless in future development of this conflict or in other conflicts. As a result, they can better mitigate risks and even profit from the occurrence of the conflict. For policy makers, dependence on resources from other countries is an ultimate outcome that can be changed through legal, administrative, and trade measures. The results of this study can assist them in enhancing their understanding of the potential economic consequences of such dependency, allowing them to better assess how to adjust the import ratios of various key international commodities.

2. Literature Review

Before the Russia-Ukraine conflict occurred, scholars had already conducted research on the impact of military or geopolitical conflicts on exchange rates. Bouraoui, & Hammami (2017) investigated five countries related to the Arab Spring, and the data results indicate a clear correlation between political instability and currency depreciation. Michail (2021) expanded the scope of data selection, based on the regression results of data from 20 countries over a period of 58 years, he found that civil wars have a significant depreciative effect on the currencies of developing countries.

There is noticeable research on the impact of global events on a country's exchange rate and the factors influencing this impact. Fratzscher (2009) found that the financial crisis that erupted in 2008 resulted in the depreciation of currencies around the world against the U.S. dollar, and macroeconomic fundamentals like countries with low FX reserve, current account position and direct financial exposure vis-a-vis the United States changed the degree of influence. Research of Njindan (2020) during the Covid-19 pandemic found that data on disease outbreaks can be used to enhance exchange rate return and volatility predictions. These studies all indicate that international events can impact exchange rates, and factors related to the events play a significant role in shaping this impact.

Regarding the Russia-Ukraine conflict, the existing literature mostly indicates that the conflict has led to depreciation of the currencies of the countries involved in the conflict and those most significantly affected (especially in the short term). Xu et al. (2023) demonstrated the link between the conflict and the depreciation of the Ruble within three months after the conflict. Chortane and Pandey (2022) discovered that the conflict had a negative impact on the Russian rouble and European currencies, while it had a positive effect on Pacific countries. Tiwari et al. (2022) proved that Although India has not actively participated in sanctions against Russia, the Indian Rupee has depreciated due to the occurrence of this conflict.

It is worth noting that in Akarsu and Gharehgozli's study (2023), they found that in countries such as Hungary, Poland, and Romania, conflicts led to a significant currency depreciation. However, the impact of conflicts on the Euro was not significant, which conflicts with findings of other scholars, such as Aliu et al. (2022). One possible reason for this could be that in the model they used, they incorporated exchange rates of other currencies against the US dollar as covariates, which they believed were not significantly affected by conflicts. Such an assumption in itself can be somewhat arbitrary. Existing studies have already demonstrated that devaluation of other currencies against the US dollar is one of the consequences of global events. Therefore, just because the Euro and other major currencies have maintained a similar degree of devaluation against the US dollar, does not necessarily imply that conflicts have not resulted in the devaluation of the Euro.

Current research mostly focuses on understanding whether conflicts have an impact on exchange rates, as well as the specific magnitude of this impact. Research that specifically identifies, the factors determining the effect of conflicts on exchange rates, resulting in varying impacts on different currencies, is relatively scarce but valuable. Lorenzoni and Werning's insightful article (2022) provides a micro-level explanation of the fluctuations in the Russian ruble. Against the backdrop of economic sanctions, the increase in demand for domestic goods in Russia ultimately led to the appreciation of the ruble. For other currencies, price changes in commodities represented by energy and food are a focal point of the study. Studies of Sokhanvar and Bouri (2023), Bagchi and Paul (2023) corroborated that the increase in commodity prices of major nations following the conflict led to changes in the exchange rates of some countries. Another significant factor of interest is geopolitical risk (GPR), scholars including Będowska-Sójka et al. (2022) and Bossman et al. (2023) have identified the connection between GPR and exchange rates in this conflict. The existence of research in both of these aspects demonstrates the feasibility of studying the dependency on Russian resources as a subject of investigation. It can be anticipated that countries more reliant on Russian resources will experience a greater impact from fluctuations in relevant resource prices in the international market following the outbreak of conflict, as well as heightened concerns in terms of geopolitical security.

This article's contribution to existing research lies in two aspects. Firstly, it explores the impact of conflicts on exchange rates by focusing on the dependency of other countries on resources, which is novel in the context of the Russia-Ukraine conflict. Secondly, it incorporates discussions on sub-events of conflicts, which could potentially serve as a useful perspective for studying events with prolonged duration.

3. Data and Descriptive Analysis

This study primarily focuses on the period from February 24, 2022, when the conflict erupted, to December 1, 2023. For the selection of state economies, this study draws on Fratzscher's research (2009) and chooses major economies globally, aiming to maintain regional balance as much as possible. Based on the sample of economies selected in Fratzscher's study, I excluded economies with currencies that were pegged to other currencies (such as the Qatari Riyal) and those that experienced excessive fluctuations during the selection period (such as the Venezuelan Bolívar). The final selection of 41 economies is shown in Table 1.

Table 1 Economy Sample

Eastern Europe	Other Parts of Europe, North America and Oceania	Middle East and Africa	Other Parts of Asia	Latin America
Bulgaria	Australia	Bahrain	China	Argentina
Czech Republic	Canada	Botswana	Hong Kong, China	Brazil
Hungary	Denmark	Egypt	India	Chile
Poland	Eurozone	Israel	Indonesia	Colombia
Romania	Iceland	Oman	Japan	Costa Rica
Serbia	New Zealand	South Africa	South Korea	Jamaica
	Norway	Tunisia	Pakistan	Mexico
	Sweden	Türkiye	Singapore	Peru
	Switzerland		Taiwan, China	
	United Kingdom		Thailand	

In Table 2, I present a total of 19 sub-events classified into 5 types. The reason for categorizing sub-events is that different types of sub-events may have varying effects on exchange rates in different directions. Different sub-events had different significance in terms of expected duration of the conflict and what kind of peace process will follow. And the markets clearly interpreted each event differently. Some sub-events, although not significantly meaningful militarily, might lead people to perceive an increased or decreased likelihood of reconciliation; other sub-events represent a military victory for one of the warring parties, but whether such a victory brings us closer to or further from a ceasefire remains uncertain. One of the important objectives of the study is to understand the impact of different types of sub-events on exchange rates, as well as the varying role of Russia's resource dependency in this process.

Table 2 Sub-Events and Their Categorization

Sub-Event Type	*Sub-Event*	*Date (MM/DD/YYYY)*
Conflict-Intensificating Sub-Events	Start of the conflict	02.24.2022
	Zaporizhzhia nuclear power plant incident	03.04.2022
	Bucha incident	04.03.2022
	Sweden and Finland joined NATO	06.29.2022
	Russia's total mobilization	09.21.2022
	Nord Stream pipeline explosion	09.26.2022
	Missile hit Poland	11.15.2022
Economic Sanctions	Russia removed from SWIFT	03.02.2022
	USA banned energy import from Russia	03.08.2022
	Price cap on Russian energy exports	09.02.2022
Conflict-Deescalating Sub-Events	Russian withdrawal from Kyiv	03.29.2022
	Opening of Black Sea ports	07.22.2022
Russian Military Victory	Capture of Mariupol	05.17.2022
	Full control over Luhansk	07.04.2022
	Capture of Bakhmut	05.22.2023
Ukrainian Military Victory	The relief of Kharkiv	09.12.2022
	Explosion at Crimea Bridge	10.08.2022
	Victory in Kherson	11.09.2022
	Wagner Group mutiny	06.26.2023

The dependent variable in this study is the the percentage change in the exchange rate from the previous day (against USD), which is calculated by taking the difference between the exchange rate on the current day and the exchange rate on the previous day, divided by the exchange rate on the previous day. Since the exchange rate here is expressed as the amount of local currency needed to buy one US dollar, a positive exchange rate change indicates a depreciation of the local currency relative to the US dollar and a negative exchange rate change indicates an appreciation of the local currency relative to the US dollar.

The independent variable is 'dependence on Russian resources,' which is calculated by dividing the amount of resources imported from Russia by the total amount of imports of that resource. If the economy is a net exporter of the resource, it is assigned a value of 0. For the specific selection of resources, three representative export resources of Russia were chosen: petroleum, gas, and cereal. It should be noted that the resources available for study in this issue are not limited to these three. The reason for choosing these three resources is that they have played important roles in both the conflict itself and the spillover effects of the conflict after the conflict. The relevant events include sanctions by Western countries on Russian petroleum and gas, the explosion of Nord Stream 2, and food shortages in countries like Egypt. Additionally, by selecting two similar energy resources and one less similar resource, it is also possible to explore whether the impacts caused by similar energy resources are similar., and if so, whether these impacts can be extrapolated to non-energy resources can also be investigated.

Control variables are categorized into two types when selected: internal fundamentals of the economies and factors indicating their relationship to the conflict. The internal fundamentals should capture as comprehensively as possible the basic economic conditions of the economies before the onset of the conflict. For this reason, I selected indicators including GDP per capita, current account/GDP ratio, sovereign rating, and foreign exchange reserve/GDP ratio, which reflect a country's development, trade, credit, and financial resilience situation. For Conflict-Related Factors, I selected two indicators: NATO participation and proximity to conflict countries (definition explained latter), both are represented as dummy variables in the model. Compared to non-NATO countries, NATO members have more pronounced military opposition to Russia, but at the same time, they are also strongly protected by the alliance. These two points differentiate their stance in this conflict from non-NATO countries. On the other hand, economies near conflict-afflicted countries evidently face greater threats compared to other economies, unless they have good relations with Russia. Therefore, I set up this dummy variable based on a) adjacency to Russia or Ukraine on land or sea, and b) having a certain degree of hostile relations with Russia. The dummy variable is set to 1 only if both requirements are satisfied. For instance, among the selected three East Asian countries, South Korea is not adjacent to Russia, and China has good relations with Russia, so this variable is set to 0 for both. However, Japan, although not directly adjacent to Russia by land, has a disputed territory under Russian control that is very close to Japan (referred to by Japan as the Northern Territories), so this variable is set to 1.

The selected time for all the above data is set to the end of 2021 or January 2022, before the outbreak of the conflict, and all have reliable data sources. The exchange rate data was sourced from Yahoo Finance; trade data was from UN Comtrade; current account and GDP per capita data were from the World Bank; sovereign ratings were from Standard & Poor's Global Ratings; foreign exchange reserves were from the central banks of respective economies.

It should be noted that, due to the adoption of the setting of exchange rates against the US dollar by various economies, all exchange rate data comes from the New York Stock Exchange, which has unified trading hours. Therefore, there will be no situation where the same sub-event corresponds to different dates for different exchange rates. Nonetheless, due to holidays observed by stock exchanges, exchange rates remain stable on those dates. As a result, the timing of certain sub-events in the model has been adjusted to the first working day following the occurrence of the sub-event.

Before setting up the model, descriptive statistics are also needed to gain a general understanding of the data.

The average exchange rate daily change before and after February of the chosen currencies shows significant difference. Prior to February 24, in the year 2022, the selected currencies exhibited a mild appreciation trend. In contrast, from the onset of the conflict on February 24, 2022, to December 1, 2023, these currencies experienced an average daily depreciation of 0.03% against the US dollar.

Upon further analysis of the data subsequent to February 24, 2022, box plots demonstrate that, relative to days without significant sub-events, the distribution of exchange rate changes for these 41 currencies was notably more skewed towards positive values on days when sub-events that intensified the conflict took place, and when economic sanctions against Russia were announced, denoting currency depreciation. In contrast, for the other three types of events, the fluctuations in exchange rates were not significantly discernible.

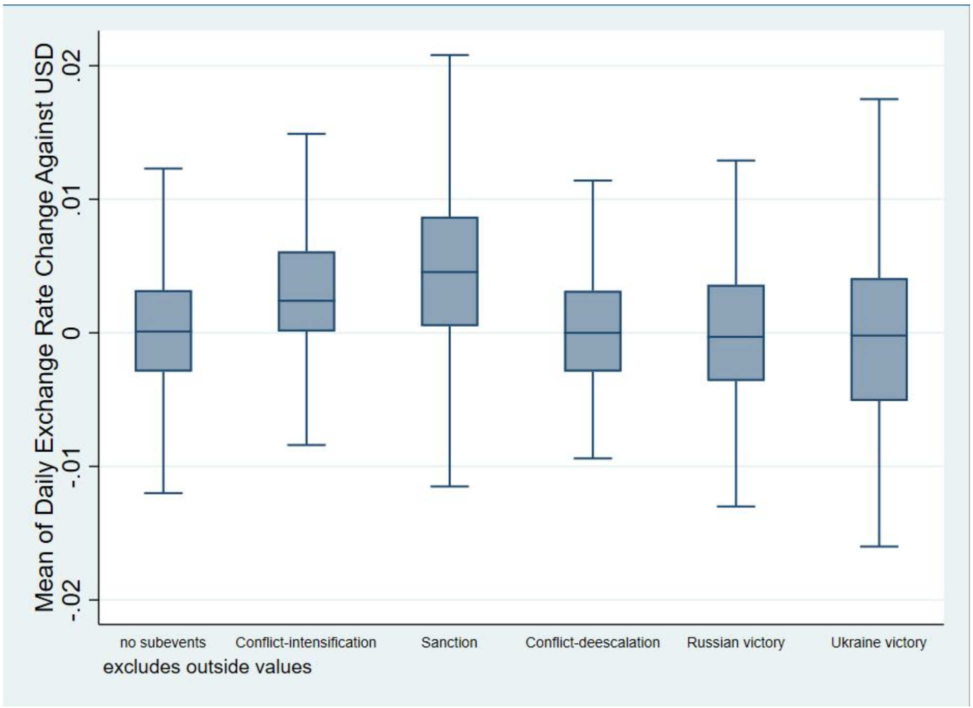

Figure 1 Distribution of Exchange Rate Changes, Grouped According to Sub-Event Situations

The mean values of the data further substantiate the observations made previously. On dates when sub-events that escalated the conflict occurred and when economic sanctions against Russia were announced, the mean changes in exchange rates reached 0.0034 and 0.0052, respectively, approximately 15 and 22 times higher than on dates without significant sub-events. Also, in this graph, two more phenomenons can be discovered. On dates when sub-events that mitigated conflicts occurred, the selected currencies averagely experienced a greater degree of depreciation against USD, and on dates when Ukraine achieved military victories, an appreciation is observed.

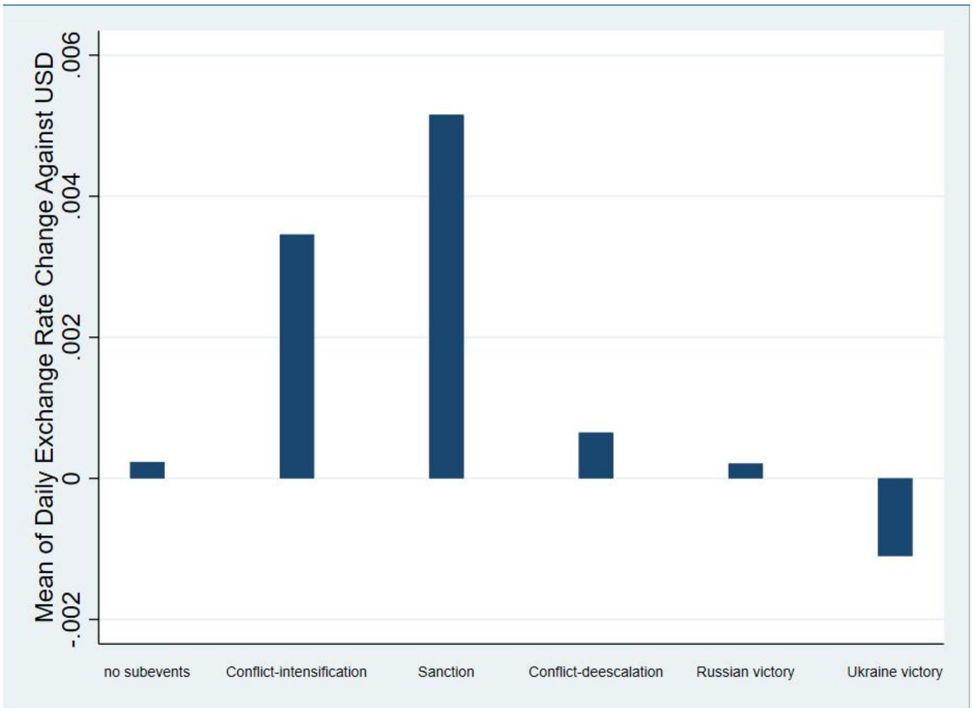

Figure 2 Average Exchange Rate Changes, Grouped According to Sub-Event Situations

I categorize countries/regions based on their dependence on Russian petroleum/gas into three groups : "0%", "0%-20%", and ">20%", and dependence on Russian cereal into three groups: "0%", "0%-5%", and ">5%".

The average performances of different dependence groups are shown in Figure 3, 4 and 5. In the same sub-event type, dependence groups are arranged from left to right in ascending order based on dependence.

Observing the performance of exchange rates for economies in different groups under the backdrop of Russia-Ukraine conflict sub-events, it is evident that there is a very strong correlation between dependency on Russian resources and exchange rate change.

Regardless of how dependency is defined, for the two types of sub-events associated with an average notable depreciation of currencies, it is evident that economies with a higher degree of dependency experienced more significant deprecation of their currencies. Conversely, for dates on which sub-events that mitigated the conflict occurred, the magnitude of exchange rate fluctuations slightly decreased with an increase in dependency level. On days marked by Ukrainian military victories, the extent of appreciation diminished as dependency levels rose for dependence defined by petroleum and gas. However, on dates corresponding to Russian military victories, no clear trend related to dependency was observed.

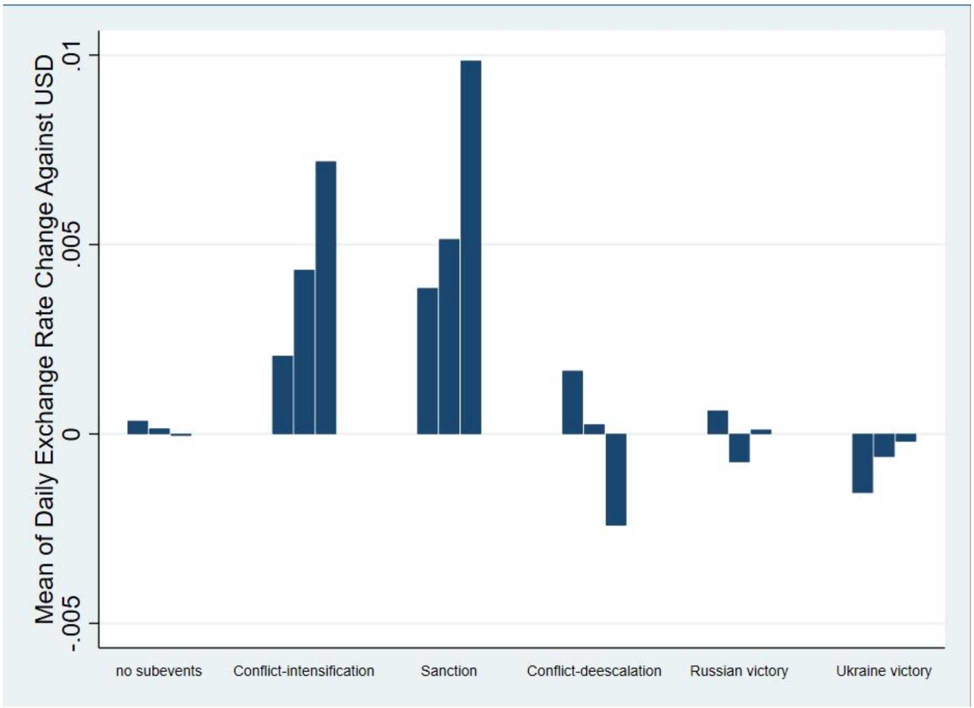

Figure 4 Average Exchange Rate Changes of Economies with 0%, 0%-20% and >20% Petroleum Dependence Level on Russia, Grouped According to Sub-Event Situations

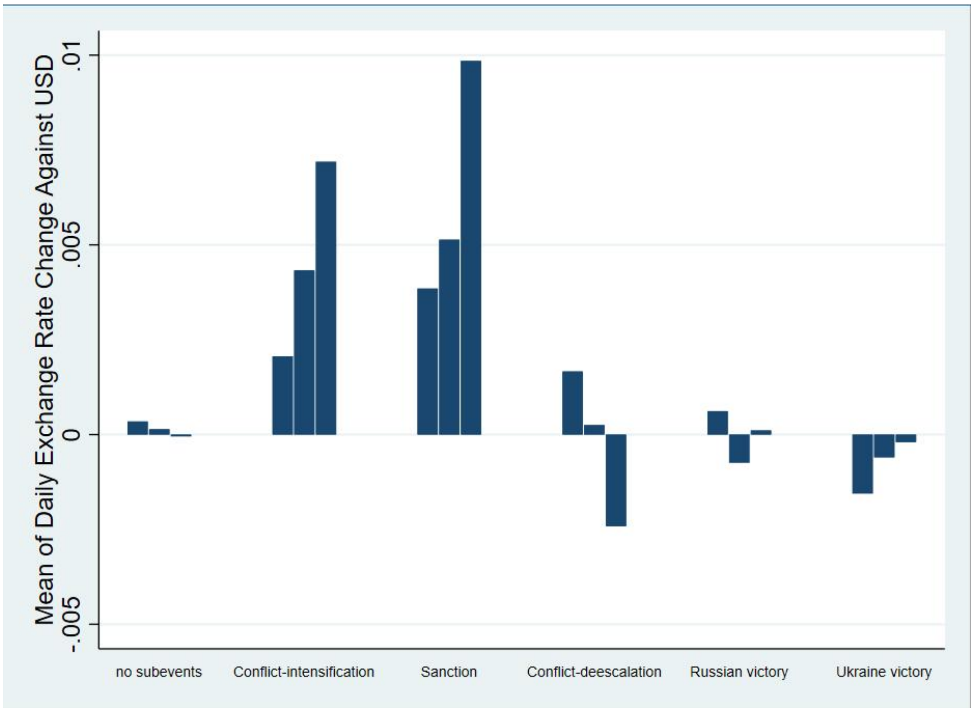

Figure 5 Average Exchange Rate Changes of Economies with 0%, 0%-20% and >20% Gas Dependence Level on Russia, Grouped According to Sub-Event Situations

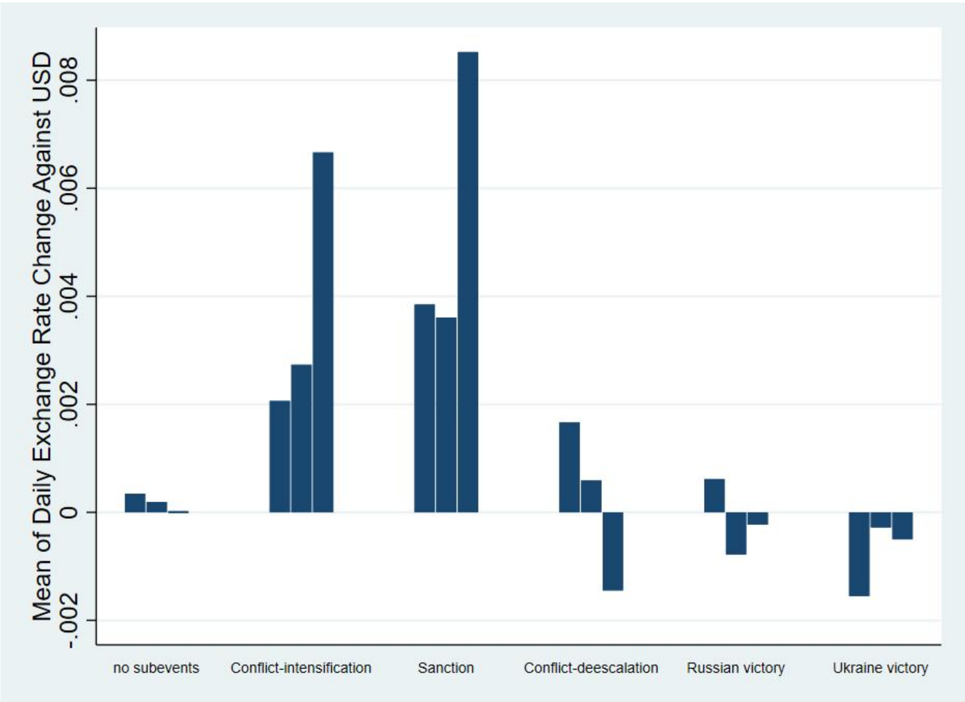

Figure 6 Average Exchange Rate Changes of Economies with 0%, 0%-5% and >5% Gas Dependence Level on Russia, Grouped According to Sub-Event Situations

4. Model

I used a mixed effects regression with a random linear trend effect for the study.

Different economies clearly exhibit distinct characteristics and behavioral patterns that cannot all be captured by control variables, leading to serial autocorrelation in data from the same economies. In such cases, mixed-effects models can capture individual differences, thus providing a more accurate description of the data's trend. Moreover, such differences likely involve trends in exchange rate fluctuations over time. Therefore, random trend model is considered a better fit compared with random intercept model. The decision not to use a quadratic or more complex random trend effect was due to concerns about overly complicating the model. In fact, the likelihood-ratio test conducted after the regression also confirmed that the random linear trend effect was the best choice.

The model is formulated as:

Within-countries model:

$$\Delta E_{ij} = b_{0i} + b_{1i} EventA_{ij} + b_{2i} EventB_{ij} + b_{3i} EventC_{ij} + b_{4i} EventD_{ij} + b_{5i} EventE_{ij} + b_{6i} Time_{ij} + \varepsilon_{ij}$$

Between-countries models:

$$\begin{aligned}
b_{0i} &= \beta_0 + \beta_{01} D_i + \beta_{02} S_i + \beta_{03} F_i + v_{0i} \\
b_{1i} &= \beta_1 + \beta_{11} D_i + \beta_{12} S_i + \beta_{13} F_i \\
b_{2i} &= \beta_2 + \beta_{21} D_i + \beta_{22} S_i + \beta_{23} F_i \\
b_{3i} &= \beta_3 + \beta_{31} D_i + \beta_{32} S_i + \beta_{33} F_i \\
b_{4i} &= \beta_4 + \beta_{41} D_i + \beta_{42} S_i + \beta_{43} F_i \\
b_{5i} &= \beta_4 + \beta_{41} D_i + \beta_{42} S_i + \beta_{43} F_i \\
b_{6i} &= v_{1i}
\end{aligned}$$

Where ΔE_{ij} is the percentage change in exchange rate compared to the previous day of economy i on a particular day t during the crisis period; D_i represents the degree of dependency on Russian resources, which can be indicated by the import conditions of petroleum, natural gas, and cereal; $Eventa/b/c/d/e$ are dummy variables, which are 1 on the date corresponding to the type of sub-event, and 0 otherwise.

S_i and F_i are control variables, representing internal fundamentals of the economies (including GDP per capita, current account/GDP ratio, sovereign rating, and foreign exchange reserve/GDP ratio) and factors indicating their relationship to the conflict (including NATO participation and proximity to conflict countries). In the study, nested models with only these two types of control variables are also included to confirm whether they are indispensable for the model.

The design of the model is aimed at comprehensively considering the overall impact of the Russia-Ukraine conflict as an event and the additional impact of sub-events related to the conflict. Clearly, both the former and the latter could be correlated with the independent and control variables in the model. In this model, for dates without sub-events occurring, the final exchange rate change is simulated solely by the fixed effects in coefficient b_{0i} and random effects. However, for dates with sub-events occurring, apart from the fixed effects in coefficient b_{0i} applicable to all post-conflict dates, there are also separate fixed effects corresponding to each type of sub-event (for instance, b_{1i} for dates when conflict-intensifying sub-events occurred). In this way, I can infer the average impact of independent and control variables on exchange rate changes after conflicts occur based on the coefficient values and significance of fixed effects in b_{0i}. Similarly, I can determine whether the impact of these variables significantly differs during sub-events from the overall average impact over the entire period based on the coefficient values and significance of fixed effects in $b_{1i/2i/3i/4i/5i}$. If the coefficient β_{01} corresponding to the independent variable in b_{0i} is significantly different from zero, it suggests that dependence on Russian resources is likely significantly correlated with exchange rate changes over the entire period after the Russia-Ukraine conflict. If $\beta_{11/21/31/41/51}$ are significantly different from zero, it indicates that on the dates when corresponding types of sub-events occur, dependence on Russian resources significantly leads to differences in exchange rate changes compared to when no sub-events occur.

Although the regression model setup cannot establish a direct causal relationship between the independent and dependent variables, it can still clarify whether there is a clear association between the two, especially on days when sub-events occur. Given the diverse and complex factors that have influenced the past two years, it may be challenging to provide a precise estimation of the overall impact during that period. However, for specific dates when sub-events occurred, the model can still accurately capture the correlation between Russia's resource dependency and exchange rate fluctuations.

5. Results

In this section, I will present and analyze the mixed regression results using dependence on Russian petroleum, natural gas, and cereal as independent variables. It is important to note that the analysis involves comparing three outcomes, which leads to a multiple comparisons problem and makes it more likely to have type 1 errors than the p-values indicate. Given that there are only three outcomes, this should not pose a serious issue, but it still needs to be acknowledged.

In order to make the results more intuitive and easy to present, the dependent variable, exchange rate changes, is measured in the model with a unit of 1%, meaning that a coefficient of 1 for a factor implies that a one-unit change in this factor leads to a 1% difference (for instance, from 0.01% to 1.01%) in the exchange rate change. Furthermore, the variables GDP per Capita and Current Account / GDP Ratio were divided by 1000 in the model to ensure that their coefficients are not significantly different in magnitude from other coefficients.

Table 3 presents the results of the regression model and its nested models when using petroleum to define dependence on Russian resources.

Without considering sub-events, the dependence on Russian resources, like most other control variables, shows an insignificant relationship with the dependent variable. This implies that in a time span of nearly two years., dependence on Russian petroleum is not significantly associated with currency devaluation. There could be several reasons for this result.

Firstly, the data used in this study is based on daily cycles, and the inherent volatility of exchange rates may make the relationship between variables and exchange rates less significant.

Secondly, there are numerous other long-term factors that could influence exchange rates (e.g., the Federal Reserve's interest rate cycles), which are difficult to account for and somewhat disrupt the data.

Lastly, and most likely, over the long term, dependence on Russian resources (petroleum) may indeed not be a significant factor leading to currency devaluation. "Sovereign rating" is the only significant variable in the absence of considering sub-events, with a negative coefficient. Considering the period selected involves severe global economic turbulence, it can be inferred that currencies of economies with better credit ratings are more favored by the market, leading to appreciation compared to those with poor credit ratings.

Table 3 Regression Results with Dependence Defined by Petroleum

Variables			**Regression Results**		
Event Interaction:		***Country Characteristics:***	**(1) Internal Fundamentals Controled**	**(2) Conflict-Related Factors Controled**	**(3) Both Controled**
			Coef. (std. err.)	*Coef. (std. err.)*	*Coef. (std. err.)*
\	*	Dependency on Russian Petroleum	-0.0375	-0.0667	-0.0772
			(0.0385)	*(0.0529)*	*(0.0567)*
		GDP per Capita	0.0005		0.0003
			(0.0004)		*(0.0005)*
		Current Account / GDP Ratio	-0.0001		-0.0001
			(0.0000)		*(0.0000)*
		Sovereign Rating	-0.0375 ***		-0.0065 ***
			(0.0385)		*(0.0025)*
		Foreign Exchange Reserve / GDP Ratio	0.0304		0.0371
			(0.0895)		*(0.0885)*
		Proximity to Conflict Countries		0.0040	0.0127
				(0.0271)	*(0.0242)*
		NATO Participation		0.0000	0.0168
				(0.0233)	*(0.0242)*
Conflict-Intensificating Sub-Events	*	\	0.1349	0.1717 ***	0.1197
			(0.1792)	*(0.0556)*	*(0.1795)*
		Dependency on Russian Petroleum	1.0479 ***	0.4174	0.6603 *
			(0.2429)	*(0.2965)*	*(0.3627)*
		GDP per Capita	0.0049		0.0027
			(0.0031)		*(0.0035)*
		Current Account / GDP Ratio	-0.0002		-0.0002
			(0.0003)		*(0.0003)*
		Sovereign Rating	-0.0025		3.00E-04
			(0.0156)		*(0.0157)*
		Foreign Exchange Reserve / GDP Ratio	-0.0676		-0.0072
			(0.5646)		*(0.5669)*
		Proximity to Conflict Countries		0.1868	0.1604
				(0.1518)	*(0.1551)*
		NATO Participation		0.2509 *	0.1393
				(0.1303)	*(0.1565)*

		\	0.0203	0.3399 ***	0.0165
			(0.2725)	*(0.0846)*	*(0.2730)*
		Dependency on Russian Petroleum	0.0115***	0.7399 *	1.1031*
			(0.3693)	*(0.4509)*	*(0.5516)*
		GDP per Capita	0.0007		0.0001
			(0.0046)		*(0.0053)*
		Current Account / GDP Ratio	-0.0004		-0.0004
Economic Sanctions	*		*(0.0004)*		*(0.0004)*
		Sovereign Rating	0.0246		0.0255
			(0.0237)		*(0.0186)*
		Foreign Exchange Reserve / GDP Ratio	-0.1082		-0.0958
			(0.8586)		*(0.8621)*
		Proximity to Conflict Countries		0.1089	0.0955
				(0.2308)	*(0.2359)*
		NATO Participation		0.1941	0.0131
				(0.1981)	*(0.2381)*
		\	-0.0553	0.0983	-0.0727
			(0.3333)	*(0.1034)*	*(0.3340)*
		Dependency on Russian Petroleum	-0.7599 *	-0.6508	-1.1812
			(0.4518)	*(0.5516)*	*(0.6748)*
		GDP per Capita	-0.0043		-0.0067
			(0.0057)		*(0.0064)*
		Current Account / GDP Ratio	0.0006		0.0007
Conflict-Deescalating Sub-Events	*		*(0.0005)*		*(0.0005)*
		Sovereign Rating	0.0156		0.0186
			(0.0290)		*(0.0092)*
		Foreign Exchange Reserve / GDP Ratio	0.1157		0.1878
			(1.0504)		*(1.0547)*
		Proximity to Conflict Countries		0.1060	0.1276
				(0.2823)	*(0.2886)*
		NATO Participation		-0.0295	0.1823
				(0.2424)	*(0.2912)*

Note: "*", "**", and "***" respectively represent significance levels at 10%, 5%, and 1%.

Russian Military Victory	*	\	-0.0533	-0.0123	-0.0595
			(0.2725)	*(0.0846)*	*(0.2730)*
		Dependency on Russian Petroleum	0.0491	0.1127	-0.6753
			(0.3693)	*(0.4509)*	*(0.5516)*
		GDP per Capita	-0.0026		-0.0034
			(0.0047)		*(0.0053)*
		Current Account / GDP Ratio	-0.0001		-0.0000
			(0.0004)		*(0.0004)*
		Sovereign Rating	0.0084		0.0092
			(0.0237)		*(0.0239)*
		Foreign Exchange Reserve / GDP Ratio	-0.0895		0.0371
			(0.8586)		*(0.0885)*
		Proximity to Conflict Countries		-0.07269	-0.0398
				(0.2308)	*(0.2359)*
		NATO Participation		0.0353	0.0999
				(0.1981)	*(0.23805)*
Ukrainian Military Victory	*	\	-0.1404	-0.18 **	-0.1333
			(0.2362)	*(0.0733)*	*(0.2367)*
		Dependency on Russian Petroleum	0.4739	0.2055	0.6665
			(0.3202)	*(0.3909)*	*(0.4783)*
		GDP per Capita	0.0033		0.0044
			(0.0040)		*(0.0046)*
		Current Account / GDP Ratio	-0.0008 **		-0.0008 **
			(0.0004)		*(0.0004)*
		Sovereign Rating	-0.0049		-0.0062
			(0.02056)		*(0.0207)*
		Foreign Exchange Reserve / GDP Ratio	0.3562		0.329
			(0.7444)		*(0.7475)*
		Proximity to Conflict Countries		-0.0966	-0.0998
				(0.2001)	*(0.2045)*
		NATO Participation		0.1365	-0.056
				(0.1718)	*0.2064)*

Note: "*", "**", and "***" respectively represent significance levels at 10%, 5%, and 1%.

For the interaction terms of sub-events, the situation is different. While almost all variables' interaction terms with sub-events are not significant, for the independent variable of interest in this study - dependence on Russian resources (petroleum), when conflict-escalating sub-events or economic sanctions occur, its interaction term with sub-events has a significantly positive coefficient (at the 10% significance level). For conflict-escalating sub-events, the coefficient of the independent variable is 0.0066, meaning that when other variables controlled and the overall effect of the conflict excluded, on dates when conflict-escalating sub-events happened, an increase of 1% in the dependence on Russian petroleum suggests a increased depreciating exchange rate (against USD) change of approximately 0.0066%. For dates when economic sanctions take place, an increase of 1% for the dependence on Russian petroleum suggests a increased depreciating exchange rate (against USD) change of 0.011%, which is even larger than the conflict-escalating case.

For other types of events, the coefficients related to the independent variables are not significant. The influence of controlled variables is also not significant in the vast majority of cases.

For two nested models (model 1 and 2 in table 3) , it can be observed that the model including internal fundamentals is overall more similar to the full model in terms of results. The two significant coefficients related to the independent variables remain significant, and their significance even increases to within the 1% level. However, for the model with only conflict-related factors, its results exhibit noticeable distortions compared to the full model. This suggests that, in controlling variables, internal fundamentals are likely to be the primary factors influencing exchange rate changes compared to conflict-related factors.

Table 4 presents the results of the regression model and its nested models when using gas to define dependence on Russian resources.

The results obtained from this model are very similar to those obtained when defining the independent variable as petroleum. A possible reason is that both are fossil energy resources exported in large quantities by Russia. Countries that import a large amount of Russian petroleum also tend to import a large amount of Russian natural gas, and vice versa.

For coefficients related to the independent variables, very similar to the petroleum case, only the interaction terms with the first two events remain statistically significant. Compared to the model using petroleum-defined independent variables, the values of these two coefficients in this model are both slightly smaller, but their significance is higher (significant on 5% level, compared with 10% for the petroleum case).

Table 4 Regression Results with Dependence Defined by Gas

Variables			**Regression Results**		
Event Interaction:		***Country Characteristics:***	**(1) Internal Fundamentals Controled**	**(2) Conflict-Related Factors Controled**	**(3) Both Controled**
			Coef. (std. err.)	*Coef. (std. err.)*	*Coef. (std. err.)*
\	*	Dependency on Russian Gas	-0.0116	-0.0139	-0.0155
			(0.0308)	*(0.0391)*	*(0.0405)*
		GDP per Capita	0.0006		0.0007
			(0.0005)		*(0.0005)*
		Current Account / GDP Ratio	-0.0001 *		-0.0001
			(0.0000)		*(0.0000)*
		Sovereign Rating	-0.0073 ***		-0.0073 ***
			(0.0024)		*(0.0024)*
		Foreign Exchange Reserve / GDP Ratio	0.0394		0.0416
			(0.0890)		*(0.0899)*
		Proximity to Conflict Countries		-0.0057	0.0022
				(0.0262)	*(0.0233)*
		NATO Participation		-0.0098	0.0024
				(0.0236)	*(0.0247)*
Conflict-Intensificating Sub-Events	*	\	0.0718	0.1647 ***	0.0842
			(0.1782)	*(0.0560)*	*(0.1783)*
		Dependency on Russian Gas	0.7904 ***	0.3529	0.5273 **
			(0.1943)	*(0.2163)*	*(0.2559)*
		GDP per Capita	0.0045		0.0025
			(0.0030)		*(0.0033)*
		Current Account / GDP Ratio	-0.0002		-0.0002
			(0.0002)		*(0.0003)*
		Sovereign Rating	0.0028		2.60E-03
			(0.0153)		*(0.0153)*
		Foreign Exchange Reserve / GDP Ratio	-0.2568		-0.105
			(0.5610)		*(0.5669)*
		Proximity to Conflict Countries		0.2424 *	0.0025 *
				(0.1451)	*(0.1470)*
		NATO Participation		0.2369 *	0.1194
				(0.1306)	*(0.1558)*

Economic Sanctions	*	\	-0.0466	0.3263 ***	-0.0385
			(0.2710)	*(0.0846)*	*(0.2711)*
		Dependency on Russian Gas	0.9668 ***	0.6510 **	0.9071 **
			(0.2954)	*(0.3289)*	*(0.3891)*
		GDP per Capita	0.0007		0.0003
			(0.0046)		*(0.0050)*
		Current Account / GDP Ratio	-0.0004		-0.0005
			(0.0004)		*(0.0004)*
		Sovereign Rating	0.0288		0.0282
			(0.0233)		*(0.0233)*
		Foreign Exchange Reserve / GDP Ratio	-0.3027		-0.2611
			(0.8532)		*(0.8639)*
		Proximity to Conflict Countries		0.2069	0.2319
				(0.2207)	*(0.2235)*
		NATO Participation		0.1624	-0.0484
				(0.1986)	*(0.2369)*
Conflict-Deescalating Sub-Events	*	\	-0.0099	0.1048	-0.0079
			(0.3316)	*(0.1042)*	*(0.3317)*
		Dependency on Russian Gas	-0.5845	-0.4309	-0.7356
			(0.3614)	*(0.4024)*	*(0.4760)*
		GDP per Capita	-0.0040		-0.0052
			(0.0057)		*(0.0061)*
		Current Account / GDP Ratio	0.0006		0.0007
			(0.0005)		*(0.0005)*
		Sovereign Rating	0.012		0.0124
			(0.0285)		*(0.0286)*
		Foreign Exchange Reserve / GDP Ratio	0.2514		0.3315
			(1.0438)		*(1.0569)*
		Proximity to Conflict Countries		0.0170	-0.0301
				(0.2700)	*(0.2735)*
		NATO Participation		-0.03963	0.1428
				(0.2430)	*(0.2912)*

Russian Military Victory	*	\	-0.0575	-0.0106	-0.0564
			(0.0027102)	*(0.0008521)*	*(0.0027109)*
		Dependency on Russian Gas	-0.0118	0.0001	-0.1442
			(0.2954)	*(0.3289)*	*(0.3891)*
		GDP per Capita	-0.0028		-0.0039
			(0.0046)		*(0.0050)*
		Current Account / GDP Ratio	-0.0001		0.0000
			(3.98E-09)		*(4.12E-09)*
		Sovereign Rating	0.0095		0.0099
			(0.0233)		*(0.0233)*
		Foreign Exchange Reserve / GDP Ratio	-0.1049		-0.0356
			(0.8532)		*(0.8639)*
		Proximity to Conflict Countries		-0.0558	-0.0484
				(0.2207)	*(0.2236)*
		NATO Participation		0.0571	0.1346
				(0.1986)	*(0.2369)*
Ukrainian Military Victory	*	\	-0.1673	-0.1848 **	-0.1692
			(0.2350)	*(0.0739)*	*(0.2350)*
		Dependency on Russian Gas	0.4253 *	0.2064	0.5102
			(0.2562)	*(0.2852)*	*(0.3373)*
		GDP per Capita	0.0034		0.0041
			(0.0040)		*(0.0046)*
		Current Account / GDP Ratio	-0.0008 **		-0.0008 **
			(0.0003)		*(0.0004)*
		Sovereign Rating	-0.0036		-0.0037
			(0.0202)		*(0.0202)*
		Foreign Exchange Reserve / GDP Ratio	0.2798		0.23362
			(0.7397)		*(0.7490)*
		Proximity to Conflict Countries		-0.0698	-0.0113
				(0.1914)	*(0.1938)*
		NATO Participation		0.1209	-0.0681
				(0.1722)	*(0.2054)*

Table 5 present the results of the regression model and its nested models when using cereal to define dependence on Russian resources.

Table 5 Regression Results with Dependence Defined by Cereal

Variables			**Regression Results**		
Event Interaction:		***Country Characteristics:***	**(1) Internal Fundamentals Controled**	**(2) Conflict-Related Factors Controled**	**(3) Both Controled**
			Coef. (std. err.)	*Coef. (std. err.)*	*Coef. (std. err.)*
\	*	Dependency on Russian Cereal	0.1981 **	0.3088 ***	0.2270 **
			(0.0777)	*(0.0740)*	*(0.0815)*
		GDP per Capita	0.0005		0.0005
			(0.0004)		*(0.0004)*
		Current Account / GDP Ratio	-0.0001		-0.0001
			(0.0000)		*(0.0000)*
		Sovereign Rating	-0.0051 **		-0.0045 *
			(0.0024)		*(0.0025)*
		Foreign Exchange Reserve / GDP Ratio	0.038		0.026
			(0.0826)		*(0.0829)*
		Proximity to Conflict Countries		0.0118	0.0126
				(0.0227)	*(0.0218)*
		NATO Participation		-0.0298	-0.0209
				(0.0184)	*(0.0194)*
Conflict-Intensificating Sub-Events	*	\	0.0565	0.1924 ***	0.1788
			(0.2057)	*(0.0570)*	*(0.2092)*
		Dependency on Russian Cereal	-0.0191	-0.5096	-0.4987
			(0.5276)	*(0.4820)*	*(0.5582)*
		GDP per Capita	0.0011		-0.0001
			(0.0030)		*(0.0030)*
		Current Account / GDP Ratio	-0.0001		-0.0001
			(0.0003)		*(0.0003)*
		Sovereign Rating	0.0159		1.60E-03
			(0.0163)		*(0.0168)*
		Foreign Exchange Reserve / GDP Ratio	-0.3631		0.0035
			(0.5609)		*(0.5679)*
		Proximity to Conflict Countries		0.2201	0.2275
				(0.1477)	*(0.1493)*
		NATO Participation		0.3584 **	0.3491 *
				(0.1197)	*(0.1326)*

Economic Sanctions	*	\	0.0113	0.3830 ***	0.1322
			(-0.4168)	*(0.0867)*	*(0.1322)*
		Dependency on Russian Cereal	0.9668	-1.1396	-0.8978
			(0.8024)	*(0.7330)*	*(0.8488)*
		GDP per Capita	-0.0030		-0.0041
			(0.0046)		*(0.0046)*
		Current Account / GDP Ratio	-0.0003		-0.0003
			(0.0004)		*(0.0004)*
		Sovereign Rating	0.04		0.026
			(0.0248)		*(0.0255)*
		Foreign Exchange Reserve / GDP Ratio	-0.427		-0.072
			(0.8530)		*(0.8636)*
		Proximity to Conflict Countries		0.1542	0.1948
				(0.2247)	*(0.2270)*
		NATO Participation		‘0.3971 **	0.3500 *
				(0.1820)	*(0.2016)*
Conflict-Deescalating Sub-Events	*	\	-0.0280	0.0853	-0.0773
			(0.3827)	*(0.1061)*	*(0.3892)*
		Dependency on Russian Cereal	0.1652	0.1086	0.3757
			(0.9816)	*(0.8968)*	*(1.0384)*
		GDP per Capita	-0.0016		0.0005
			(0.0056)		*(0.0050)*
		Current Account / GDP Ratio	0.0050		0.0095
			(0.0005)		*(0.0005)*
		Sovereign Rating	0.0041		0.0124
			(0.0303)		*(0.0312)*
		Foreign Exchange Reserve / GDP Ratio	0.3278		0.1988
			(1.0435)		*(1.0565)*
		Proximity to Conflict Countries		0.0147	-0.0162
				(0.2748)	*(0.2777)*
		NATO Participation		-0.1611	-0.1529
				(0.2227)	*(0.2467)*

Russian Military Victory *	\	-0.0587	-0.0088	0.0916
		(0.3128)	*(0.0867)*	*(0.2016)*
	Dependency on Russian Cereal	0.0078	-0.0664	-0.1187
		(0.8024)	*(0.7330)*	*(0.8488)*
	GDP per Capita	-0.0028		-0.0029
		(0.0046)		*(0.0046)*
	Current Account / GDP Ratio	-0.0001		-0.0001
		(0.0004)		*(0.0004)*
	Sovereign Rating	0.0094		0.0068
		(0.0248)		*(0.0255)*
	Foreign Exchange Reserve / GDP Ratio	-0.1035		-0.0504
		(0.8530)		*(0.8636)*
	Proximity to Conflict Countries		-0.0596	0.0212
			(0.2247)	*(0.1968)*
	NATO Participation		0.0606	0.0916
			(0.1820)	*(0.2016)*
Ukrainian Military Victory *	\	-0.3233	-0.1915	-0.3016
		(0.2712)	*(0.0752)*	*(0.2758)*
	Dependency on Russian Cereal	0.7502	0.528	0.6605
		(0.6957)	*(0.6355)*	*(0.7360)*
	GDP per Capita	0.0007		0.0005
		(0.0039)		*(0.0040)*
	Current Account / GDP Ratio	-6.00E-04		-6.00E-04
		(0.0004)		*(0.0004)*
	Sovereign Rating	0.0126		0.0001
		(0.0215)		*(0.0221)*
	Foreign Exchange Reserve / GDP Ratio	0.2113		0.2717
		(0.7396)		*(0.7488)*
	Proximity to Conflict Countries		-0.0354	0.0212
			(0.1948)	*(0.1968)*
	NATO Participation		0.1486	0.0652
			(0.1578)	*(0.1748)*

In this research question, cereal is fundamentally different from petroleum and gas as an export resource. Specifically regarding Russia's exports, its position in cereal exports is not as high as in the energy sector. However, Ukraine, another conflicting party in the conflict, while not prominent in the energy field like Russia, is a major exporter of cereals, which to some extent compensates for this difference. Additionally, concerning energy resources, European countries are more developed have the highest dependency on Russia. As for cereals, many European countries can be self-sufficient, but some developing countries that are closer to Russia have a higher dependency on Russian exports. Based on current news and research, some countries such as Egypt have indeed encountered crises following the conflict. (Abay et al., 2023)

The regression results indeed confirm the differences between cereal and the first two types of resources. Without considering sub-events, there is a significant impact between dependency on Russian cereal and exchange rate changes, which was not evident in the first two regressions. Controlling for other variables, a 1% higher dependency on Russian cereal during the conflict period is associated with an average daily currency depreciation of 0.002%. Given the length of the selected time period, the magnitude of this impact is quite significant. In the controlled variables, sovereign ratings still maintain significance, further proving that sovereign rating is a crucial factor affecting exchange rate changes over long periods following conflicts.

However, the model's performance is poor when considering sub-events. Unlike the previous two models, none of the coefficients related to the independent variables are significant. For the conflict-intensificating sub-events and economic sanctions that were significant in the previous two models, even the sign of their coefficients no longer aligns with expectations in this model. Clearly, this implies that dependency on Russian cereal does not affect the role of sub-events during conflicts on exchange rate changes.

6. Conclusion

Does the economic dependence of economies on Russia's resources affect exchange rate changes? I believe this article provides evidence for an affirmative answer. Through regression models, whether using petroleum, gas, or cereals as representatives of resources, it can be observed that there is a significant connection between dependence on Russia's resources and changes in exchange rates.

The further idea put forth in this article (which is also validated by the models) is that this relationship is not evenly distributed over time post-conflict. The long-term impact of the conflict itself on exchange rate changes and the influence of significant sub-events during the conflict on exchange rate changes coexist, with dependence on Russia's resources playing different roles in these two aspects. Long-term dependence on Russian petroleum and gas does not show a significant correlation with exchange rate fluctuations. However, during conflict-escalating sub-events and the announcement of economic sanctions dates, high dependence strongly suggests a more pronounced currency devaluation. On the contrary, high dependence on Russian cereals has a long-term devaluation effect on exchange rates. However, the occurrence of sub-events does not lead to more pronounced changes in the exchange rates of economies with high dependence on the same day.

The reality revealed by this result might be:

a) Over the long term, on average, dependence on Russian energy is unlikely to cause significant impacts on the exchange rates of economies.

b) However, in the case of important updates related to the conflict, the market is still more prone to short-term panic or optimism shifts for the economies with higher dependence on Russian energy.

c) On the other hand, for economies highly dependent on Russian cereals (mostly populous developing countries), their exchange rates will face more severe depreciation impacts in the long term. This could be due to the fact that the impact of disrupted grain imports is inherently devastating for them, or it could be because their governments and economic systems are ill-equipped to handle the impact on exchange rates.

This study identified the existence and approximate scale of the relationships mentioned above, but it was unable to determine specific causal mechanisms or causality. For currency investors, the former is already sufficient, but for academic researchers and some policymakers, there are still more questions open to be answered. Subsequent research can achieve this by refining daily-level data into hourly or minute-level data, or by optimizing models using methods that allow for more in-depth causal analysis.

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