THE RUSSO-UKRAINIAN CONFLICT AND CARBON EMISSIONS: EMPIRICAL EVIDENCE FROM CHINA

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Abstract. The Russo-Ukrainian conflict has disrupted global energy markets and profoundly influenced carbon emissions dynamics in various countries. This study investigates the impact of the Russo-Ukrainian conflict on carbon emissions in China and its contributing factors. Using daily carbon emissions data from five major economic sectors in China between 2021 and 2022, this study applies a difference-in-differences approach and designs a quasi-natural experiment targeting the conflict. Empirical results indicate that the Russo-Ukrainian conflict significantly reduced China's carbon emissions by approximately 27.7%. Further sectoral regression analyses reveal that the aviation sector experienced the most significant decline in carbon emissions, whereas the industrial and power sectors exhibited relatively smaller changes. Additionally, this study constructs a mediation effect model, identifying global crude oil price increases as a critical transmission mechanism. Specifically, the conflict elevated global crude oil prices, which subsequently reduced China's carbon emissions. By empirically demonstrating the impact of the Russo-Ukrainian conflict on China's carbon emissions, this study provides evidence of the intricate relationship between geopolitical conflicts and carbon emissions. The findings also offer insights into developing more targeted low-carbon policies for China and other major carbon-emitting nations.
Keywords: *energy prices, differences-in-differences model, mediation effect analysis, sectoral carbon emissions*

Introduction

On February 24, 2022, the Russo-Ukrainian conflict escalated into a full-scale military operation by Russia against Ukraine. By 2024, this ongoing conflict had resulted in a humanitarian crisis but also caused widespread political and economic disruptions globally. As the conflict intensified, NATO and other countries imposed comprehensive economic sanctions on Russia. Given Russia's critical role in the global energy export market, export restrictions became one of the primary means of economic sanctions against Russia (Huang et al., 2024). The global energy market, interconnected through international trade (Li et al., 2020), has experienced substantial volatility due to these sanctions, fundamentally altering international energy trade patterns. Most notably, supply chain disruptions have triggered a significant surge in global energy prices. However, the implications of energy price fluctuations for global environmental governance remain uncertain. On one hand, European Union (EU) countries, heavily reliant on affordable Russian crude oil and natural gas resources (Liu et al., 2023), were prompted by the sanctions to accelerate their transition to renewable energy reducing dependence on fossil fuels. In the short term, however, inadequate alternative energy supplies forced some regions to revert to high-carbon-emissions traditional energy sources (Tzeremes et al., 2023). On the other hand, due to variations in industrial and energy structures among countries, global energy market fluctuations had heterogeneous

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impacts based on differing policy responses to fossil fuels. Against this backdrop of a global energy crisis, China, as the world's largest energy consumer, presented a critical case for understanding changes in energy consumption and greenhouse gas emissions during the Russo-Ukrainian conflict, offering key insights into the ripple effects on global energy market stability and climate governance. Therefore, conducting an in-depth investigation into the impact of the Russo-Ukrainian conflict on China's carbon emissions is significant, as it not only enhances our understanding of the environmental effects of geopolitical events but also provides a scientific basis for formulating policies to address climate shocks in China and other major economies.

As the world's second-largest economy, China's rapid development in recent years has been inseparable from the extensive use of fossil fuels (Zhou et al., 2019).

According to the International Energy Agency (IEA), carbon dioxide emissions related to global energy use rose by 1.1% in 2023, an increase of 410 million tons, bringing the total to a record 37.4 billion tons. Among these, China's carbon dioxide emissions grew by approximately 565 million tons in 2023, reaching 12.6 billion tons of carbon dioxide (CO_2) equivalent, making it one of the largest carbon emitters globally (Chen et al., 2023). Despite significant investments in renewable energy and the implementation of various policies encouraging clean energy development in recent years (Ao et al., 2023), the heavy reliance on traditional energy sources, particularly coal, remains a significant obstacle to achieving energy transition in China (Zhou et al., 2019). At this critical juncture of energy transition, the Russo-Ukrainian conflict has disrupted China's energy consumption structure and its carbon reduction process. Specifically, the conflict's impact on China's carbon emissions remains uncertain. Apart from the green energy transition driven by rising energy prices, the obstruction of Russia's westward energy exports may compel it to implement an "eastward energy expansion" strategy, increasing energy trade with China.

This raises two critical questions: What impact has the conflict had on China's carbon emissions? What are the mechanisms underlying these impacts? This study aims to address these questions and provide potential policy recommendations.

Existing studies have provided preliminary insights into the environmental governance effects of the Russo-Ukrainian conflict. Rawtani et al. (2022) highlighted the destructive impacts of the conflict on water resources, air pollution, soil quality, and biodiversity, though their study lacked empirical evidence to substantiate these claims. Using a general equilibrium framework, Cui et al. (2023) concluded that the conflict had little effect on the progress of global carbon mitigation initiatives. Furthermore, Han et al. (2024), employing a differences-in-differences analysis based on carbon emissions data recorded before and after the conflict, found that the Russo-Ukrainian conflict significantly increased carbon emissions in European Union countries. This is primarily because the European Union is highly dependent on Russian energy, and after the outbreak of the conflict it was forced to partially resume the use of coal and other high-carbon energy sources to compensate for the shortage of natural gas, which led to an increase in carbon emissions. In contrast, China's energy structure and policy responses have distinctive features, as domestic coal supply plays a dominant role and the degree of import dependence is significantly lower than that of the EU. Based on this difference, the expected impact of the Russo-Ukrainian conflict on China's carbon emissions appears to differ from that in the EU. Liu et al. (2023) investigated the impact of the Russo-Ukrainian conflict on China's new energy vehicle market, finding that the conflict structurally boosted sales of new energy vehicles in China, thereby contributing positively to carbon

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reduction. However, this study only approached the issue from the perspective of new energy vehicles and did not examine the direct relationship between the Russo-Ukrainian conflict and China's carbon emissions. As a potential market for Russia's energy exports in the aftermath of the conflict, the energy cooperation between China and Russia could have complex implications for China's carbon emissions, warranting further investigation.

Against this background, this study systematically investigates the impact of the Russo-Ukrainian conflict on China's carbon emissions and its transmission mechanisms by employing daily carbon emissions data from five major sectors, namely domestic aviation, power, ground transportation, industry, and residential consumption, between 2021 and 2022, using a difference-in-differences (DID) model and mediation effect analysis. Employing a DID model and mediation effect analysis, the study aims to address the following research gaps: First, it seeks to uncover the dynamic changes in China's carbon emissions under the influence of the Russo-Ukrainian conflict and the heterogeneity of these effects across different sectors. Second, it aims to clarify the mediating role of energy price fluctuations in transmitting the conflict's impact. Third, the study aspires to provide empirical data and practical insights to support the formulation of carbon reduction policies in China and other developing countries.

The structure of this paper is as follows: Section *Literature review and theoretical hypotheses* reviews the existing literature and develops the research hypotheses. Section *Empirical strategy* introduces the empirical methodology, including research strategies and data sources. Section *Empirical analysis* presents the core empirical findings and provides corresponding analytical discussions. Finally, Section *Conclusion, policy recommendations, and limitations* concludes the study, offers policy suggestions, and outlines its limitations along with avenues for future research.

Literature review and theoretical hypotheses

The impact of the Russo-Ukrainian conflict on the global economy

As one of the largest and most far-reaching geopolitical events of the 21st century, the Russo-Ukrainian conflict has caused severe disruptions to global markets and the economic environment. A review of existing studies on the Russo-Ukrainian conflict reveals that current research primarily focuses on macroeconomic impacts (Cui et al., 2023), financial markets (Boungou and Yatié, 2022; Coulibaly, 2024), agricultural commodity markets (Carriquiry et al., 2022), and multinational corporations (Tosun and Eshraghi, 2022). First, at the macroeconomic level, Cui et al. (2023) found that the conflict had significant negative effects on the GDP of both Russia and Ukraine. Furthermore, the international sanctions triggered by the conflict exacerbated global inflationary pressures. Liadze et al. (2023) conducted an empirical analysis showing that the Russo-Ukrainian conflict led to a decline in global GDP and an increase in inflation by 1%–2%. Second, in financial markets, the outbreak of the Russo-Ukrainian conflict caused severe negative shocks to global stock markets (Boungou and Yatié, 2022). Geographically, these adverse effects were more pronounced in Europe and Asia (Yousaf et al., 2022). Due to the growing interconnectivity of the global economy, the systemic risks in financial markets caused by NATO's economic sanctions on Russia spread to countries worldwide, particularly in Europe and the Americas (Qureshi et al., 2022). Gaio et al. (2022) conducted an empirical study on stock markets in six developed countries, including the United States and the United Kingdom, and found that the Russo-Ukrainian conflict undermined the efficiency of these stock markets. Third, in commodity markets,

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the agricultural sector was among the hardest hit. As Ukraine and Russia are major global wheat exporters, the conflict reduced the supply of wheat and other crops, leading to heightened volatility in global agricultural commodity markets (Mottaleb et al., 2022). Beyond agriculture, Fang and Shao (2022) demonstrated that the conflict exacerbated volatility in financial and energy commodity markets through economic and financial channels. Lastly, regarding multinational corporations, the Russo-Ukrainian conflict diminished the implicit asset value of companies conducting business in Russia or Ukraine, especially those with operations in Russia (Boungou and Yatié, 2022). Tosun and Eshraghi (2022) performed an empirical analysis of multinational companies that continued operations in Russia after the conflict, finding that their investment portfolios underperformed compared to those of companies that exited the Russian market or aligned with market averages.

Overall, existing studies have thoroughly examined the spillover effects of the Russo-Ukrainian conflict on various political and economic dimensions. However, they lack a focus on the Chinese perspective. Given the global political and economic dynamics triggered by this geopolitical conflict, it is essential to further explore China's potential strategic responses and their possible implications during the conflict.

Geopolitical conflicts and carbon emissions

Existing research broadly agrees that geopolitical conflicts significantly influence global climate change (Carriquiry et al., 2022). Geopolitical conflicts, which may involve military actions, economic trade sanctions, and terrorism, can have multifaceted impacts on carbon emissions. The most direct impact of large-scale geopolitical conflicts arises from the extensive use of military equipment, machinery, and the mobilization of civilian production lines for military purposes, which results in substantial consumption of traditional energy resources. This process releases significant amounts of CO_2, thereby negatively affecting national carbon emissions (Wang et al., 2022; Ben Cheikh and Ben Zaied, 2023). Increased military expenditure, as a result, contributes to higher CO_2 emissions and further deteriorates regional environmental conditions (Gokmenoglu et al., 2021). Beyond military-related emissions, disruptions to trade and production caused by terrorism and economic sanctions also undermine regional carbon reduction efforts (Bildirici and Gokmenoglu, 2020). The Russo-Ukrainian conflict, characterized by prolonged military strikes, has had significant environmental implications. Both sides have targeted energy infrastructure as part of their military strategies, leading to increased CO_2 emissions in Russia and Ukraine (Pereira et al., 2022). Moreover, the conflict has far-reaching global effects. The surge in global arms procurement resulting from the conflict has imposed negative economic and environmental consequences on a broader scale (Imran et al., 2023). While restrictions on energy trade between the EU and Russia have incentivized renewable energy development in the EU, the short-term impact of these measures on carbon reduction remains limited (Cui et al., 2023).

In the context of China, scholars have explored the direct relationship between geopolitical conflicts and China's carbon emissions. Anser et al. (2021) found that geopolitical conflicts significantly reduced the ecological footprint of emerging economies like China, thereby enhancing environmental governance performance. Conversely, Adams et al. (2020) suggested that the effects of geopolitical conflicts on carbon emissions differ over time: in the short term, they tend to increase CO_2 emissions, while in the long term, they may suppress them. Although these studies provide some insights into the relationship between geopolitical conflicts and China's carbon

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emissions, few have specifically examined the impact of the Russo-Ukrainian conflict on China. As China is not a direct participant in the conflict, its impact on the country's carbon emissions is more subtle and involves more complex mechanisms. However, as a globally significant geopolitical event, the Russo-Ukrainian conflict has undoubtedly had ripple effects worldwide. Investigating its impact on China's carbon emissions is thus of great significance.

Based on this context, this study proposes the following hypothesis:

Hypothesis H1: The Russo-Ukrainian conflict has, to some extent, reduced China's carbon emissions.

Geopolitical conflicts, energy prices, and carbon emissions

Geopolitical conflicts profoundly affect global energy markets, with impacts spanning crude oil (Jiao et al., 2023), clean energy (Ding et al., 2023), and other sectors. Antonakakis et al. (2017), using monthly data from 1899 to 2016, examined the significant negative effects of geopolitical conflicts on oil returns and price volatility. These negative impacts on traditional energy sources have, to some extent, spurred the adoption of clean energy (Ben Cheikh and Ben Zaied, 2023). Sweidan (2021), employing various cointegration techniques, demonstrated the positive effects of geopolitical risks on the expansion of clean energy in the United States. In the case of the Russo-Ukrainian conflict, the global energy market has been notably disrupted by energy export restrictions. Cui et al. (2023) highlighted that Russia's energy exports primarily consist of crude oil and natural gas. On one hand, restrictions on crude oil exports have driven up international crude oil prices, forcing stakeholders to seek alternative green and clean energy sources (Alkathery et al., 2022), thereby mitigating regional carbon emissions to some extent. On the other hand, as a cleaner energy source, rising natural gas prices have directly increased carbon emissions. For instance, rising natural gas costs have prompted some enterprises to substitute coal for natural gas, intensifying pressure on carbon reduction efforts (Sha et al., 2022).

Although China's natural gas reserves are far smaller than those of Russia, the country still has relatively abundant natural gas resources, which reduce its vulnerability to rising international natural gas prices. However, the impact of global crude oil price increases on China's energy structure is more pronounced. This shift compels China to adopt other clean energy sources as substitutes for the increasingly expensive crude oil. Liu et al. (2023) highlighted that the Russo-Ukrainian conflict has significantly accelerated the development of China's new energy vehicle industry in recent years. It should be noted that if the overall effect holds, it becomes meaningful to further explore its specific transmission mechanism. Therefore, building on the preceding hypothesis, this study proposes a more targeted hypothesis as follows:

Hypothesis H2: The Russo-Ukrainian conflict has reduced China's carbon emissions by driving up global crude oil prices.

Empirical strategy

Sample and data

Following the approach of Han et al. (2024), this research analyzes how the Russo-Ukrainian conflict has affected China's carbon emissions, drawing on daily CO_2 emission data from five key industries over the period from January 1, 2021, to December 31, 2022.

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The five industries include Domestic Aviation, Power, Ground Transport, Industry, and Residential Consumption. The real-time CO_2 emissions data were sourced from a carbon emissions monitoring platform (https://www.carbonmonitor.org.cn). Additionally, other variable data were obtained from the Chocie Financial Terminal Database. A total of 3650 observations were ultimately collected for this study.

Model construction and variable selection

This paper adopts a difference-in-differences (DID) approach to systematically examine how the Russo-Ukrainian conflict has influenced carbon emissions in China. Since China is not a direct participant in the conflict, the Russo-Ukrainian conflict serves as an exogenous shock, enabling the design of a quasi-natural experiment (Han et al., 2024). To this end, the following DID model, represented by *Equation 1*, is constructed:

$$co2_{it} = \beta_1 did_{it} + \gamma_1 m2_{it} + \gamma_2 cpi_{it} + \gamma_3 ppi_{it} + c + v_t + u_i + \varepsilon_{it} \qquad \text{(Eq.1)}$$

In the model, subscripts i and $t$represent individual industries and time, respectively. β and γ are the fitted coefficients of the model, while c denotes the intercept term. To capture unobservable heterogeneity that does not vary over time or across industries, this study further incorporates monthly time-fixed effects vt and industry-fixed effects ui. εit represents the random error term.

The dependent variable in this study, $co2_{it}$ refers to the daily carbon emissions for the five industry sectors in China. The data are log-transformed for consistency and normalization in the modeling process.

The independent variable did_{it} is constructed as $did_{it} = treat * post$. Here, $treat$ serves as a binary indicator used to distinguish between groups, where samples from 2022 are identified as 1, and samples from 2021 are identified as 0. The variable post is an event dummy variable, where samples dated after February 24, 2022, the specific outbreak date of the Russo-Ukrainian conflict, are assigned a value of 1, while samples prior to this date are assigned a value of 0. Based on this construction, did_{it} represents an interaction between the group indicator variable and the event-specific dummy variable.

The control variables $m2_{it}$, cpi_{it}, and ppi_{it} correspond to the year-on-year growth rates of China's broad monetary aggregate, CPI, and PPI, respectively. In addition, this study employs the three-step mediation model (Mackinnon et al., 1995) to explore the potential mediating role of global crude oil price fluctuations in the pathway through which the Russo-Ukrainian conflict impacts China's carbon emissions. The specific mediation model is set up as follows:

$$co2_{it} = \beta_1 did_{it} + \gamma_1 m2_{it} + \gamma_2 cpi_{it} + \gamma_3 ppi_{it} + c + v_t + u_i + \varepsilon_{it} \qquad \text{(Eq.2)}$$

$$oil_{it} = \beta_2 did_{it} + \gamma_1 m2_{it} + \gamma_2 cpi_{it} + \gamma_3 ppi_{it} + c + v_t + u_i + \varepsilon_{it} \qquad \text{(Eq.3)}$$

$$co2_{it} = \beta_3 oil_{it} + \beta_4 did_{it} + \gamma_1 m2_{it} + \gamma_2 cpi_{it} + \gamma_3 ppi_{it} + c + v_t + u_i + \varepsilon_{it} \qquad \text{(Eq.4)}$$

In this context, *Equation 2* represents the first step of the mediation model test, which is the regression of the independent variable on the dependent variable and is consistent with *Equation 1*. *Equation 3* represents the second step of the mediation model test, which

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is the regression of the independent variable on the mediator variable. In this equation, oil_{it} represents the mediator variable selected for this study, specifically the daily settlement price of WTI crude oil. The third step in testing the mediation model is presented in *Equation 4*, with simultaneous inclusion of the independent, mediator, and dependent variables in the regression equation. *Table 1* provides a detailed summary of the variables mentioned in the models above.

Table 1. *Description of key variables*

Type	Variable	Type
Dependent	Carbon emissions	CO_2
Independent	DID term	did
Mediator	Crude oil price	oil
Controls	Broad money growth rate	m2
	Consumer price index	cpi
	Producer price index	ppi
	Sector fixed effects	v_t
	Month fixed effects	u_i

To validate the appropriateness of the DID approach adopted in this research, conducting a parallel trends test is essential. Parallel trends are a critical prerequisite for the applicability of the differences-in-differences model. According to the parallel trends assumption, the treated and control groups must share comparable pre-conflict growth trends before the Russo-Ukrainian conflict occurred. If this condition is not satisfied, the estimated effect of the conflict obtained through DID may not fully reflect the true causal effect, as part of the effect could be attributed to inherent differences between the treatment and control groups. There are two commonly used methods for parallel trends testing. The first method involves plotting the time trends of the treatment and control groups to visually examine whether the variables in different groups follow similar trends over time. This visual inspection helps determine whether the parallel trends assumption holds. The second method uses the event study approach, which involves generating interaction terms between monthly dummy variables Month and the treatment group dummy variable $\mathrm{treated}$. These interaction terms are then included in the model for regression analysis. Specifically, M and N represent the number of periods before and after the policy event, respectively, and the coefficient δ_j of the interaction term $\mathrm{treated_i} * \mathrm{Month_j}$ measures the difference between the treatment and control groups in the j-th period. The model is specified as follows:

$$Y_{it} = \beta_0 + \sum_{j=-M}^{N} \delta_j \mathrm{treated_i} * \mathrm{Month_j} + \varepsilon_{it} + u_i + v_t \tag{Eq.5}$$

In the above model, if the coefficients δ_j for the period from $-M$ to 0 do not show statistically significant differences, and the coefficients δ_j for certain months during the period from 0 to N are statistically significant, it indicates that the model passes the parallel trends test. To address the issue of perfect multicollinearity, it is necessary to exclude one $\mathrm{treated_i} * \mathrm{Month_j}$ interaction term. Therefore, this study excludes the first period prior to the Russo-Ukrainian conflict as the baseline group for the model.

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Descriptive statistics of variables

Table 2 reports the descriptive statistics for all variables used in the empirical analysis of this study. Additionally, to provide a clearer visualization of China's carbon emissions during 2021–2022, *Figure 1* is presented. In this figure, the darker line represents daily carbon emissions in China during 2022, while the other line depicts daily carbon emissions in 2021. At a preliminary glance, daily carbon emissions in 2022 appear to be lower than those in the same period of 2021 for an extended period following the outbreak of the Russo-Ukrainian conflict (February 24). Meanwhile, the two lines exhibit relatively consistent fluctuation trends, indicating the necessity of controlling for time effects in the empirical analysis of this study.

Table 2. *Descriptive statistics*

VarName	Obs	Mean	SD	Min	Median	Max
CO_2	3650	0.901	1.745	-3.792	0.935	2.881
did	3650	0.426	0.495	0.000	0.000	1.000
oil	3650	4.374	0.209	3.863	4.368	4.818
m2	3650	9.956	1.486	8.100	9.550	12.400
cpi	3650	1.443	0.835	-0.300	1.500	2.800
ppi	3650	6.157	4.371	-1.300	7.400	13.500

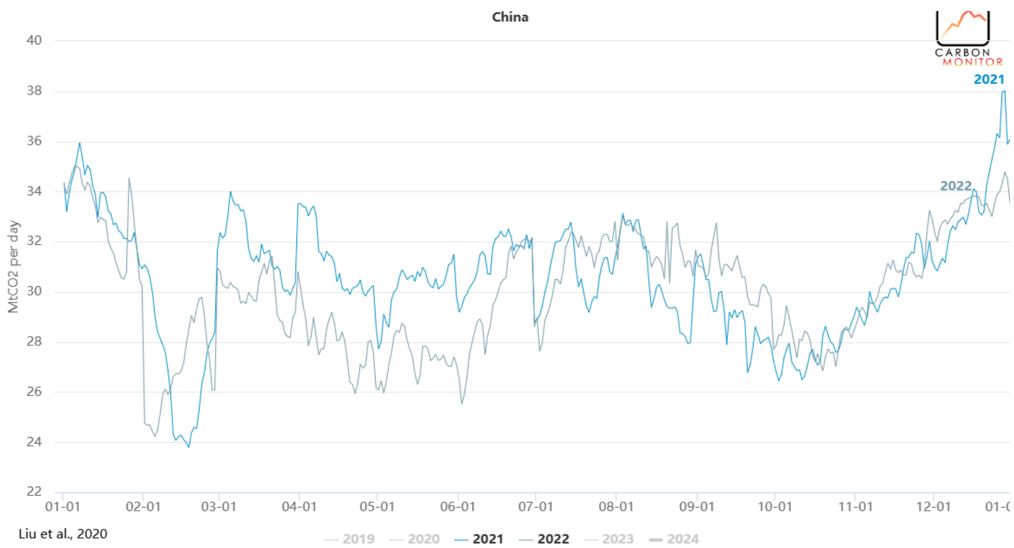

Figure 1. *Daily carbon emissions in China, 2021–2022. The estimation method for CO_2 emissions during 2021–2022 follows Liu et al. (2020). Source: https://www.carbonmonitor.org.cn/*

Before conducting the formal empirical analysis, this study first performed a Pearson correlation analysis on the variables used. *Table 3* reports the results of the Pearson correlation coefficient matrix. It can be observed that the correlation coefficient between the explanatory variable did and the dependent variable CO_2 is -0.048, which is statistically significant at the 1% level. This initial result reveals a notable negative influence of the Russo-Ukrainian conflict on China's carbon emissions.

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Table 3. *Variable correlation matrix*

	CO_2	did	oil	m2	cpi	ppi
CO_2	1					
did	-0.048***	1				
oil	-0.047***	0.734***	1			
m2	-0.033**	0.873***	0.535***	1		
cpi	-0.039**	0.728***	0.749***	0.607***	1	
ppi	0.010	-0.548***	0.051***	-0.755***	-0.079***	1

***, **, * denote significance levels of 1%, 5%, and 10%, respectively

Empirical analysis

Baseline regression

Table 4 presents the baseline regression results of this study. Using a stepwise regression approach, Columns (1)–(4) incrementally add control variables. First, it can be observed that the regression coefficient of did in Column (1) is significantly negative. Even after progressively including control variables, the coefficient of did remains significantly negative. This further demonstrates the robustness of the model. Based on the results in Column (4), the fitted coefficient is -0.277, indicating that compared to the pre-conflict period, the Russo-Ukrainian conflict reduced China's carbon emissions by 27.7%. Hypothesis H1 is thus confirmed.

Table 4. *Baseline regression results*

	(1) CO_2	(2) CO_2	(3) CO_2	(4) CO_2
did	-0.160*** (-7.276)	-0.253*** (-8.439)	-0.248*** (-8.272)	-0.277*** (-9.178)
m2		0.033*** (4.539)	0.033*** (4.487)	-0.024** (-2.023)
cpi			0.029** (2.491)	0.082*** (5.684)
ppi				-0.015*** (-6.133)
_cons	1.083*** (77.271)	0.767*** (10.798)	0.762*** (10.733)	1.356*** (11.315)
Sector	Yes	Yes	Yes	Yes
Month	Yes	Yes	Yes	Yes
N	3650	3650	3650	3650
R2	0.100	0.105	0.107	0.116

The numbers in parentheses are t-values, and ***, **, * denote significance levels of 1%, 5%, and 10%, respectively

To confirm the robustness of the main regression results, further tests are performed by adding control variables to refine the analysis of how the Russo-Ukrainian conflict

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affects China's carbon emissions. As shown in *Table 5*, Column (1) adds the macroeconomic climate index (index), while Column (2) adds the consumer confidence index (confidence). Although the magnitude of the DID coefficient declines notably, it remains significantly negative, and the model's R-squared value improves slightly. Thus, the introduction of these additional controls proves effective, demonstrating the robustness of the baseline model.

Table 5. *Robustness check results*

	(1) **CO_2**	**(2)** **CO_2**
did	-0.123*** (-3.496)	-0.110*** (-3.100)
m2	-0.017 (-1.456)	0.008 (0.533)
cpi	0.030* (1.921)	0.034** (2.196)
ppi	0.014*** (3.251)	0.008* (1.646)
index	0.051*** (8.303)	0.041*** (5.530)
confidence		0.005** (2.464)
_cons	-3.915*** (-6.063)	-3.713*** (-5.707)
Sector	Yes	Yes
Month	Yes	Yes
N	3650	3650
R2	0.133	0.134

The numbers in parentheses are t-values, and ***, **, * denote significance levels of 1%, 5%, and 10%, respectively

Given that this study's carbon emission data primarily derive from five key Chinese industries, *Table 6* presents the aggregate emissions figures for each sector during the two-year span. Clear differences in emissions among these industries are observed. As a result, the sector identified as having the lowest emissions is assigned to Sample 1, whereas the other four higher-emitting sectors constitute Sample 2 for further subgroup regression tests.

Table 6. *Carbon emissions of China's five major sectors*

Department	**2021CO_2**	**2022CO_2**
Domestic Aviation	56.982	34.735
Ground Transport	907.602	875.070
Industry	4332.674	4177.363
Residential	798.531	816.244
Power	5076.467	5225.2451

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Table 7 presents the results of the subgroup regressions. The results show that in Group 1, the fitted coefficient of the did variable is -1.117, which is statistically significant at the 1% level; in Group 2, the fitted coefficient of the did variable is -0.067, which is statistically significant at the 5% level. Comparing these results with the full-sample regression, it is evident that the absolute value of the fitted coefficient in Group 2 decreases significantly. Since the Domestic Aviation sector has a relatively small absolute level of CO_2 emissions, the relative fluctuations caused by the Russo-Ukrainian conflict are larger, leading to a 111.7% reduction in CO_2 emissions after the conflict. In contrast, the four other sectors with large CO_2 emissions experienced smaller relative fluctuations, resulting in a 6.7% reduction in CO_2 emissions following the conflict. The subgroup regression results align with the direction of the baseline regression results, indicating that the model has passed the robustness check.

Table 7. *Subgroup regression results*

	All CO_2	Group 1 CO_2	Group 2 CO_2
did	-0.277*** (-9.178)	-1.117*** (-14.250)	-0.067** (-2.439)
m2	-0.024** (-2.023)	-0.029 (-0.943)	-0.022** (-2.098)
cpi	0.082*** (5.684)	0.240*** (6.422)	0.042*** (3.216)
ppi	-0.015*** (-6.133)	-0.042*** (-6.606)	-0.008*** (-3.699)
_cons	1.356*** (11.315)	-1.565*** (-5.034)	2.086*** (19.046)
Sector	Yes	Yes	Yes
Month	Yes	Yes	Yes
N	3650	730	2920
R2	0.116	0.449	0.179

The numbers in parentheses are t-values, and ***, **, * denote significance levels of 1%, 5%, and 10%, respectively

Parallel trends test

This study conducted a parallel trends test over a 10-day window before and after the Russo-Ukrainian conflict. As shown in *Figure 2*, the confidence intervals pass through the horizontal zero axis prior to the outbreak of the Russo-Ukrainian conflict. However, after the conflict, the confidence intervals shift significantly downward, and from the fifth day onward, they remain entirely below the horizontal zero axis. This indicates that the model passes the endogeneity test.

Placebo test

This study first conducted a placebo test using randomly assigned treatment groups. Samples were randomly selected as the treatment group, and the DID model was applied. This random sampling process was repeated 500 times, generating regression coefficients

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and p-values for each iteration, which are summarized in *Figure 3*. The results show that the distribution of coefficients closely resembles a normal distribution, with most fitted coefficients clustered around 0. Additionally, the p-values are relatively high, approaching 1, indicating that the results from the randomly assigned treatment groups are not statistically significant. A horizontal dashed line was plotted at the 0.05 significance level threshold, and only a small fraction of the regression results passed the 5% significance test. The fitted coefficient of the did variable for the actual treatment group is -0.230, demonstrating that most randomly sampled coefficients are far from the actual fitted coefficient of -0.277.

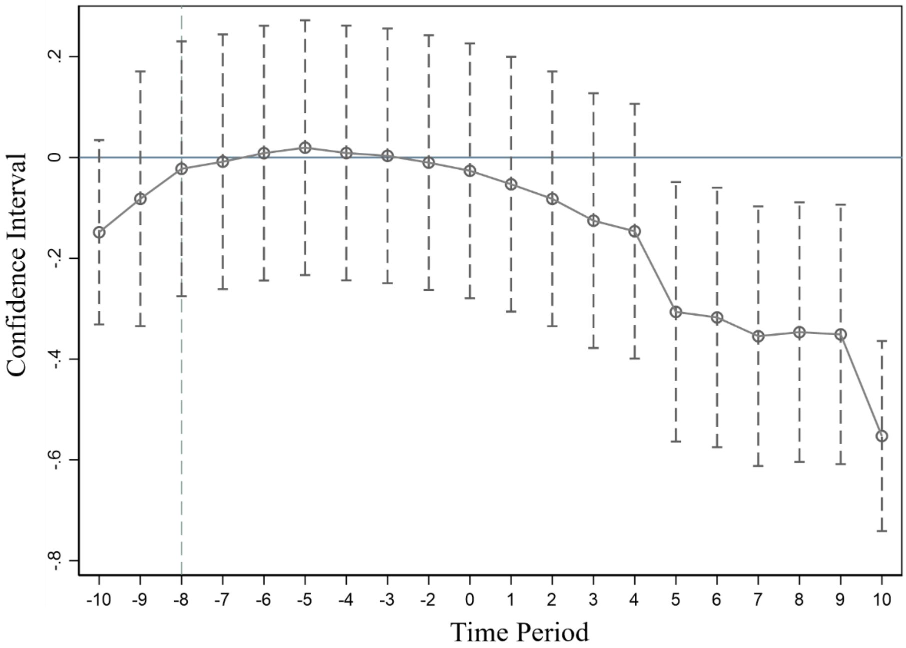

Figure 2. *Parallel trends test*

Mechanism analysis

Table 8 reports the three-step mediation model regression results with crude oil price as the mediator variable. The results show that the first step regression indicates a significantly negative coefficient for the did variable, confirming that the Russo-Ukrainian conflict significantly reduced China's carbon emissions. The second step regression shows a significantly positive coefficient for the did variable, indicating that the Russo-Ukrainian conflict significantly increased global oil prices. The third step regression reveals a significantly negative coefficient for the oil variable, suggesting that the increase in oil prices significantly reduced China's carbon emissions. In conclusion, this evidence supports the significant mediating role of energy prices, where the Russo-Ukrainian conflict led to higher energy prices, and the increase in oil prices further suppressed China's carbon emissions. Hypothesis H2 is thus confirmed.

Furthermore, a placebo test with randomly assigned conflict dates was conducted. A random date between 2021 and 2022 was selected as the conflict outbreak date, and the DID model was applied. This random date selection process was also repeated 500 times, generating regression coefficients and p-values, which are summarized in a similar graph. The results show that the distribution of coefficients closely follows a normal distribution,

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with most coefficients clustered around 0 and high p-values approaching 1, indicating that the results from the randomly assigned conflict dates are not statistically significant. A horizontal dashed line was plotted at the 0.05 significance level threshold, and only a small fraction of the regression results passed the 5% significance test. The fitted coefficient of the did variable for the actual conflict date is -0.230, demonstrating that most randomly sampled coefficients are far from the actual fitted coefficient of -0.277. Based on the above analyses, it can be concluded that the empirical model used in this study passes the placebo test.

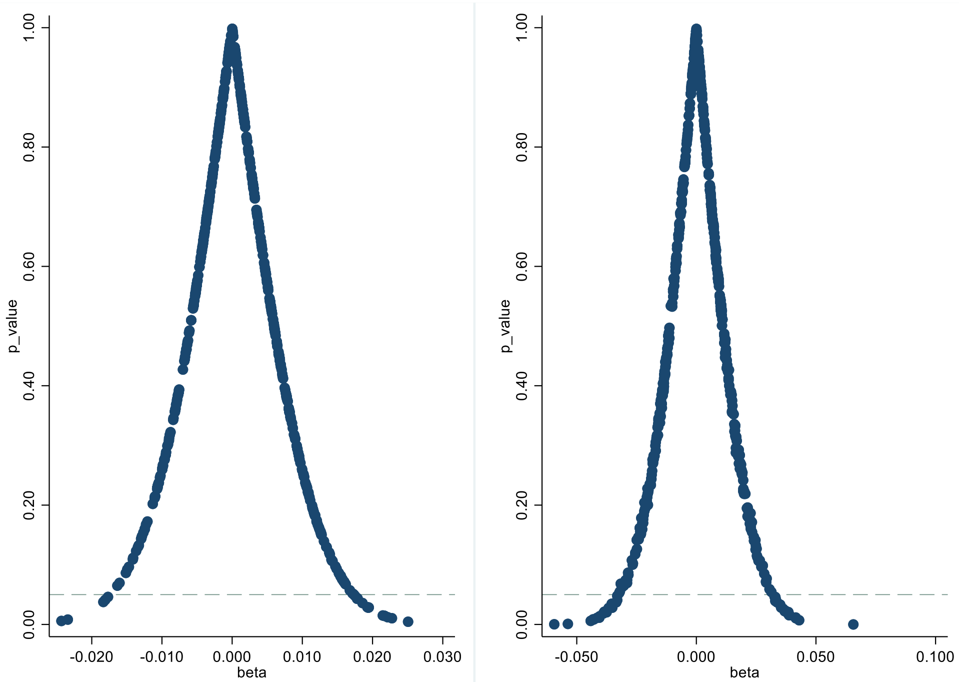

Figure 3. *Placebo test results*

Table 8. *Mediation model results*

	(1) CO_2	(2) oil	(3) CO_2
did	-0.277*** (-9.178)	0.184*** (31.059)	-0.231*** (-6.795)
oil			-0.253*** (-2.990)
ppi	-0.024** (-2.023)	0.043*** (18.647)	-0.013 (-1.050)
m2	0.082*** (5.684)	-0.017*** (-6.159)	0.077*** (5.357)
cpi	-0.015*** (-6.133)	0.035*** (72.495)	-0.006 (-1.622)
_cons	1.356*** (11.315)	3.616*** (153.761)	2.269*** (6.914)
Sector	Yes	Yes	Yes
Month	Yes	Yes	Yes
N	3650	3650	3650
R2	0.116	0.861	0.118

The numbers in parentheses are t-values, and ***, **, * denote significance levels of 1%, 5%, and 10%, respectively

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Conclusion, policy recommendations, and limitations

Conclusions and discussions

Utilizing daily carbon emission data from five major economic sectors in China for the period of 2021–2022, this study employs the DID approach to empirically analyze the aggregate impact of the Russo-Ukrainian conflict on China's emissions and examines possible transmission mechanisms. The baseline regression demonstrates a significant decline in China's carbon emissions following the conflict, a conclusion confirmed by subsequent robustness analyses. Sector-specific regressions further reveal that carbon emissions from the domestic aviation sector were more sensitive to the conflict relative to other sectors. Additionally, mediation tests indicate that the conflict's effect on reducing China's carbon emissions primarily operates through elevated global crude oil prices.

It should be noted that the impact of the Russo-Ukrainian conflict on China's carbon emissions seems to be in the opposite direction from that in Europe. This is mainly because the EU, heavily dependent on Russian fossil fuels, was forced to resume coal and other high-carbon energy sources after the conflict, which raised its emissions. In contrast, China's stronger energy autonomy and lower reliance on Russian imports, together with measures that promoted clean energy substitution and efficiency improvements, helped to restrain emissions. Consequently, differences in energy structure, policy orientation, and import dependence provide a plausible explanation for the divergent carbon emission trajectories of China and the EU.

Policy recommendations

Considering the findings discussed above, the paper presents the following policy suggestions:

First, the Russo-Ukrainian conflict underscores vulnerabilities associated with global fossil fuel reliance, emphasizing China's potential exposure to high-carbon energy risks. Thus, China should prioritize investments in clean energy R&D and strengthen renewable energy infrastructures such as solar and wind power. Meanwhile, accelerating the integration of regional energy networks can significantly enhance distribution efficiency. Given the uncertainties of geopolitical events affecting energy markets, China needs to implement a more responsive and flexible energy policy system. Real-time monitoring and timely policy adjustments will enable China to mitigate adverse impacts arising from unforeseen shocks, safeguarding domestic energy stability and environmental protection.

Second, the results of this study show that energy prices play a key role in the dynamic changes in carbon emissions. Therefore, the government should use policy tools such as tax incentives to guide reasonable fluctuations in energy prices, encouraging enterprises and consumers to opt for low-carbon energy. Additionally, a price stabilization fund for energy prices could be established to mitigate the negative effects of international energy price fluctuations on the domestic market. The study also indicates that sectors like aviation and transportation are among the most significantly impacted by energy price fluctuations. As such, the government should introduce policies to support the research, development, and use of new energy vehicles, as well as optimize the construction of charging infrastructure. Additionally, low-carbon public transportation solutions, such as the development of green rail transit and new energy bus fleets, should be considered.

Third, the Russo-Ukrainian conflict demonstrates the inseparable link between energy security and international cooperation. China should continue to promote energy

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cooperation under the "Belt and Road Initiative" at both international and regional levels. By strengthening energy cooperation with Central Asia, Southeast Asia, and Africa through the "Belt and Road" initiative, for example, China could expand its natural gas pipeline network with Central Asian countries, promote the transfer of clean energy technology, and build a more stable clean energy supply chain. Moreover, China should actively engage in the formulation of global energy governance rules, such as advocating for the establishment of a fair and transparent international energy trade mechanism under the frameworks of the United Nations and G20, and promoting a global carbon pricing system to enhance China's voice in global energy governance.

Limitations and future directions

Despite providing a comprehensive analysis of the linkage between the Russo-Ukrainian conflict and China's carbon emissions through the lens of energy markets, this study still has certain limitations. First, the sampling period is relatively short. As the Russo-Ukrainian conflict continues into 2024, this research can only assess its short-run impact on China's carbon emissions. However, the green transition of energy is a long-term and ongoing process, which means that this study does not significantly capture the long-term impact of the conflict on China's carbon emissions. Future research could incorporate data from additional years to capture long-term effects and explore the dynamic impact of geopolitical conflicts on carbon emissions.

Second, although this study highlights the role of energy prices as a mediator variable, geopolitical conflicts may also influence carbon emissions through other channels, such as international trade, financial market fluctuations, and so on. This study did not extensively extend the analysis to these areas. Therefore, future research could combine multidimensional data and dynamic models to explore more complex transmission mechanisms.

Finally, the data used in this study mainly comes from macro-level data in China. However, the real-world situation is more complex, as different sectors and industries may face different carbon emission choices due to the Russo-Ukrainian conflict. This makes the exploration of the environmental governance effects of the Russo-Ukrainian conflict lacking micro-level empirical evidence. In the future, as more data becomes available, micro-level analysis could be conducted to examine the impact of the conflict on individuals and enterprises.

REFERENCES

[1] Adams, S., Adedoyin, F., Olaniran, E., Bekun, F. V. (2020): Energy consumption, economic policy uncertainty and carbon emissions; causality evidence from resource rich economies. – Economic Analysis and Policy 68: 179-190.

[2] Alkathery, M. A., Chaudhuri, K., Nasir, M. A. (2022): Implications of clean energy, oil and emissions pricing for the GCC energy sector stock. – Energy Economics 112: 106-119.

[3] Anser, M. K., Syed, Q. R., Lean, H. H., Alola, A. A., Ahmad, M. (2021): Do economic policy uncertainty and geopolitical risk lead to environmental degradation? Evidence from Emerging Economies. – Sustainability 13:58-66

[4] Antonakakis, N., Gupta, R., Kollias, C., Papadamou, S. (2017): Geopolitical risks and the oil-stock nexus over 1899-2016. – Finance Research Letters 23: 165-173.

[5] Ao, Z. W., Fei, R. L., Jiang, H. W., Cui, L. X., Zhu, Y. X. (2023): How can China achieve its goal of peaking carbon emissions at minimal cost? A research perspective from shadow

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1087110887

price and optimal allocation of carbon emissions. – Journal of Environmental Management 325: 116458.

[6] Ben Cheikh, N., Ben Zaied, Y. (2023): Renewable energy deployment and geopolitical conflicts. – Journal of Environmental Management 344: 118561.

[7] Bildirici, M., Gokmenoglu, S. M. (2020): The impact of terrorism and FDI on environmental pollution: evidence from Afghanistan, Iraq, Nigeria, Pakistan, Philippines, Syria, Somalia, Thailand and Yemen. – Environmental Impact Assessment Review 81: 106340.

[8] Boungou, W., Yatié, A. (2022): The impact of the Ukraine-Russia war on world stock market returns. – Economics Letters 215: 110516.

[9] Carriquiry, M., Dumortier, J., Elobeid, A. (2022): Trade scenarios compensating for halted wheat and maize exports from Russia and Ukraine increase carbon emissions without easing food insecurity. – Nature Food 3: 847-850.

[10] Chen, X. H., Tee, K., Elnahass, M., Ahmed, R. (2023): Assessing the environmental impacts of renewable energy sources: a case study on air pollution and carbon emissions in China. – Journal of Environmental Management 345: 118525.

[11] Coulibaly, S. (2024): Russia-Ukraine war and the cost of borrowing in the West African Economic and Monetary Union sovereign debt market. – African Development Review-Revue Africaine De Developpement 36: 108-120.

[12] Cui, L. B., Yue, S. Y., Nghiem, X. H., Duan, M. (2023): Exploring the risk and economic vulnerability of global energy supply chain interruption in the context of Russo-Ukrainian war. – Resources Policy 81: 103373.

[13] Ding, S. S., Wang, K. H., Cui, T. X., Du, M. (2023): The time-varying impact of geopolitical risk on natural resource prices: the post-COVID era evidence. – Resources Policy 86: 104-161.

[14] Fang, Y., Shao, Z. Q. (2022): The Russia-Ukraine conflict and volatility risk of commodity markets. – Finance Research Letters 50: 103264.

[15] Gaio, L. E., Stefanelli, N. O., Pimenta, T. Jr., Bonacim, C. A. G., Gatsios, R. C. (2022): The impact of the Russia-Ukraine conflict on market efficiency: evidence for the developed stock market. – Finance Research Letters 50: 103302.

[16] Gokmenoglu, K. K., Taspinar, N., Rahman, M. M. (2021): Military expenditure, financial development and environmental degradation in Turkey: a comparison of CO_2 emissions and ecological footprint. – International Journal of Finance & Economics 26: 986-997.

[17] Han, L. N., Zhou, Z. X., Shi, B. F., Wang, Y. (2024): Challenges to environmental governance arising from the Russo-Ukrainian conflict: evidence from carbon emissions. – Journal of Environmental Management 349: 119481.

[18] Huang, G. H., Chen, L. N., Luo, B. (2024): International trade sanctions imposed due to the Russia-Ukraine war may cause unequal distribution of environmental and health impacts. – Communications Earth & Environment 5: 569.

[19] Imran, M., Khan, S., Khan, H. U. R., Jambari, H., Musah, M. B., Zaman, K. (2023): War psychology: the global carbon emissions impact of the Ukraine-Russia conflict. – Frontiers in Environmental Science 11: 1065301.

[20] Jiao, J. W., Yin, J. P., Xu, P. F., Zhang, J., Liu, Y. (2023): Transmission mechanisms of geopolitical risks to the crude oil market — a pioneering two-stage geopolitical risk analysis approach. – Energy 283: 128449.

[21] Li, Y. L., Chen, B., Li, C. H., Li, Z., Chen, G. Q. (2020): Energy perspective of Sino-US trade imbalance in global supply chains. – Energy Economics 92: 104959.

[22] Liadze, I., Macchiarelli, C., Mortimer-Lee, P., Juanino, P. S. (2023): Economic costs of the Russia-Ukraine war. – World Economy 46: 874-886.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1087110887

[23] Liu, L. J., Jiang, H. D., Liang, Q. M., Creutzig, F, Liao, H., Yao, Y. F., Qian, X. Y., Ren, Z. Y., Qing, J., Cai, Q. R., Edenhofer, O., Wei, Y. M. (2023a): Carbon emissions and economic impacts of an EU embargo on Russian fossil fuels. – Nature Climate Change 13: 290-+.

[24] Liu, W., Chen, X., Zhang, J. H. (2023b): The Russia-Ukraine conflict and the automotive energy transition: empirical evidence from China. – Energy 284: 128562.

[25] Liu, Z., Ciais, P., Deng, Z., Lei, R., Davis, S. J., Feng, S., Zheng, B., Cui, D., Dou, X., Zhu, B. (2020): Near-real-time monitoring of global CO2 emissions reveals the effects of the COVID-19 pandemic. – Nature Communications 11(1): 5172.

[26] Mackinnon, D. P., Warsi, G., Dwyer, J. H. (1995): A simulation study of mediated effect measures. – Multivariate Behavioral Research 30, 41-62.

[27] Mottaleb, K. A., Kruseman, G., Snapp, S. (2022): Potential impacts of Ukraine-Russia armed conflict on global wheat food security: a quantitative exploration. – Global Food Security-Agriculture Policy Economics and Environment 35: 100659.

[28] Pereira, P., Basic, F., Bogunovic, I., Barcelo, D. (2022): Russian-Ukrainian war impacts the total environment. – Science of the Total Environment 837: 155865.

[29] Qureshi, A., Rizwan, M. S., Ahmad, G., Ashraf, D. (2022): Russia-Ukraine war and systemic risk: Who is taking the heat? – Finance Research Letters 48: 103036.

[30] Rawtani, D., Gupta, G., Khatri, N., Rao, P. K., Hussain, C. M. (2022): Environmental damages due to war in Ukraine: a perspective. – Science of the Total Environment 850: 157932.

[31] Sha, R., Ge, T., Li, J. Y. (2022): How energy price distortions affect China's economic growth and carbon emissions. – Sustainability 14: 7312.

[32] Sweidan, O. D. (2021): The geopolitical risk effect on the US renewable energy deployment. – Journal of Cleaner Production 293: 126189.

[33] Tosun, O. K., Eshraghi, A. (2022): Corporate decisions in times of war: evidence from the Russia-Ukraine conflict. – Finance Research Letters 48: 102920.

[34] Tzeremes, P., Dogan, E., Alavijeh, N. K. (2023): Analyzing the nexus between energy transition, environment and ICT: a step towards COP26 targets. – Journal of Environmental Management 326: 116598.

[35] Wang, K. H., Kan, J. M., Jiang, C. F., Su, C. W. (2022): Is geopolitical risk powerful enough to affect carbon dioxide emissions? Evidence from China. – Sustainability 14: 7867.

[36] Yousaf, I., Patel, R., Yarovaya, L. (2022): The reaction of G20+ stock markets to the Russia-Ukraine conflict "black-swan" event: evidence from event study approach. – Journal of Behavioral and Experimental Finance 35: 100723.

[37] Zhou, N., Price, L., Dai, Y. D., Creyts, J., Khanna, N., Fridley, D., Lu, H. Y., Feng, W., Liu, X., Hasanbeigi, A., Tian, Z. Y., Yang, H. W., Bai, Q., Zhu, Y. Z., Xiong, H. W., Zhang, J. G., Chrisman, K., Agenbroad, J., Ke, Y., McIntosh, R., Mullaney, D., Stranger, C., Wanless, E., Wetzel, D., Yee, C., Franconi, E. (2019): A roadmap for China to peak carbon dioxide emissions and achieve a 20% share of non-fossil fuels in primary energy by 2030. – Applied Energy 239: 793-819.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1087110887