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The Function of Geopolitical Risk on Carbon Neutrality Under the Shadow of Russia-Ukraine Conflict: Evidence from Russia's Sectoral CO_2 Emissions by High-Frequency Data and Quantile-Based Methods

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ABSTRACT

By considering the ongoing Russia-Ukraine conflict, this study analyzes the function of the geopolitical risk index (GPR) on carbon neutrality. So, the study focuses on Russia because the recent literature has focused on mainly European countries and ignored Russia. In this context, Russia's GPR is used as the core explanatory variable, and Russia's sectoral CO_2 emissions are considered as the dependent variables and carbon neutrality indicator. Also, high-frequency daily data from January 2, 2019, to June 30, 2023, is used and novel quantile methods are performed for empirical uncovering. The results present that (i) in the domestic aviation sector, GPR decreases CO_2 emissions at all quantiles except for some upper ones; (ii) in the international aviation sector, GPR increases CO_2 emissions at middle and upper quantiles except for lower ones; (iii) in both transport and power sectors, GPR has an increasing effect at higher quantiles; (iv) in the industry sector, GPR has a mixed effect on CO_2 emissions; (v) in the residential sector, increasing GPR stimulates CO_2 emissions; (vi) there are generally causal effects from GPR to sectoral CO_2 emissions at all quantiles except for some middle (0.50-0.55) ones; (vii) the results are consistent based on the alternative econometric method. Overall, at higher quantiles, GPR stimulates all sectoral CO_2 emissions except the industry sector and the effects of GPR on sectoral CO_2 emissions vary based on quantiles. Accordingly, various policy caveats for Russia are discussed in detail.

Keywords: Geopolitical Risk, Sectoral CO_2 Emissions, Russia, Quantile Methods.

JEL Classification: C32; N54; O13

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1. INTRODUCTION

Countries have focused on development from both economic and financial perspectives until recent years (Depren et al., 2021; Kartal et al., 2022a). Such an approach has caused excessive pressure on the environment by causing higher levels of anthrophonic degradation caused by humans. In such a process, environmental problems of humanity have increased and various negative issues, such as accelerating CO_2 emissions, increasing air temperature, declining biodiversity, and stimulating climate change, have been observed naturally (Kartal et al., 2022b; Pata et al., 2023a). Hence, countries, societies, and scholars have been now more interested in issues of the environment.

Because there has been an adverse development in environmental degradation, which requires countries to be carbon neutral, many of the countries have been trying to decline their CO_2 emissions to achieve carbon neutrality. In this context, various factors have been considered. In the literature, many scholars have focused on the effect of economic growth/income (e.g., Dong et al., 2018; Bandyopadhyay & Rej 2021; Kartal et al., 2023a; Pata & Kartal, 2023; Pata et al., 2023b-c; Ullah et al., 2023), while later studies have used the role of energy consumption (e.g., Dong et al., 2018; Hassan et al., 2020; Kasperowicz et al., 2020; Kim, 2020; Piłatowska et al., 2020; Saidi & Omri, 2020; Azam et al., 2021; Pata, 2021; Belucio et al., 2022; Fareed & Pata 2022; Kartal et al., 2023b-c). the literature about the effect of income and energy has shown that economic growth without environmental concern and higher energy consumption, especially generated from fossil fuel sources, have a degrading effect on the environment (Martins et al., 2021). For this reason, an eco-friendly economic growth structure and a higher share of clean energy in the total energy mix is highly needed to prevent environmental degradation and achieve carbon neutrality target by countries (Kartal, 2023; Ulussever et al., 2023a).

While the effects of the traditional factors, such as economic growth and energy consumption as discussed above, have been known as important regressors on the environment, the most recent literature has been considering another possible point from this perspective. In the opinion of the researchers, geopolitical risk is one the most important among these factors. That is why after the Russia-Ukraine conflict has turned into a war (IEA, 2023), there has been a recent energy crisis, which has resulted from the increasing geopolitical tension due to the war (Pata et al., 2023d). So, the literature about the geopolitical risk effect on the environment has been now developing further.

When the literature is examined from this point, it can be seen that there are some studies, which have researched the effect of GPR on the environment. Pata et al. (2023d) examine the US case and determine the mainly reducing effect, whereas Ulussever et al. (2023b) focus on GCC countries and conclude generally an increasing effect of GPR on CO_2 emissions.

The literature includes further studies, such as Riti et al. (2022) for BRICS countries, Ma et al. (2022) for the selected 111 countries; Wang et al. (2022), Du and Wang (2023), and Li (2023) for the case of China. These studies have mainly concluded that GPR has a curbing effect on CO_2 emissions, whereas Ulussever et al. (2022b) present an increasing effect of GPR on CO_2 emissions in GCC countries and Pata and Ertuğrul (2023) conclude an insignificant effect of GPR on CO_2 emissions in India. Hence, the literature about GPR's effect on the environment has not come to a consensus yet. Moreover, there are various studies in the literature, that consider the Russia-Ukraine war (e.g., Pereira et al., 2022; Qureshi et al., 2022; Ratten, 2023), increasing geopolitical risk, and the current energy crisis. However, such studies have mainly examined the effects on the EU countries and ignored Russia's side (e.g., Rawtani et al., 2022). Hence, as can be seen from the before-mentioned literature overview, it can be stated that the literature has a gap.

Considering the literature gap defined, this study focuses on the case of Russia in investigating the effect of geopolitical risk on carbon neutrality. In this context, the study uses CO_2 emissions as the carbon neutrality indicator to capture the most recent up-to-date high-frequency daily data available between January 2, 2019, and June 30, 2023. Besides, the study considers sectoral CO_2 emissions in Russia for a deepened analysis. Moreover, the study applies novel quantile-based methods. Using such an approach, this study investigates the potential answers to the following questions of the research; (i) what is the function of the geopolitical risk on carbon neutrality in Russia?; (ii) is the effect of geopolitical risk on carbon neutrality nonlinear or does the effect vary according levels (i.e., quantiles); (iii) is the effect at a causality level across quantiles or is there any difference? The summarized results of the study reveal that geopolitical risk increases all sectoral CO_2 emissions except for in the industry sector and the effects on sectoral CO_2 emissions vary based on quantiles.

The study provides some contributions; (i) the study handles the Russia case, which is one of the parties of the current geopolitical tension with Ukraine. Hence, by differing from the many studies in the literature, this study focuses on Russia rather than EU countries; (ii) the study uses the most recent up-to-date data until 2023 June end. So, the study examines the most recent time by including increasing geopolitical tensions and the current energy crisis; (iii) the study performs novel quantile-based econometric methods. Hence, the effects are examined based on over levels (i.e., quantiles).

By following the IMRAD approach, the second section presents the methods; the third section reveals empirical results; and the fourth section presents the conclusion and policy caveats.

2. MODEL SPECIFICATION AND DATA

2.1. Data

This study focuses on the case of Russia and analyzes the function of geopolitical risk on sectoral CO_2 emissions. In this context, daily data from January 2, 2019, to June 30, 2023, is used. Data for sectoral CO_2 emissions of Russia is obtained from Carbonmonitor (2023) and the unit for CO_2 emissions is $MtCO_2$, while data for Russia's geopolitical risk index is gathered from matteoiacoviello.com (2023), and the unit for it is basis point.

GPR data is transformed into daily frequency in line with studies in the literature (Balcılar et al., 2016; Adebayo et al., 2023; Shahbaz et al., 2023). Also, Moreover, logarithmically differentiated time series are used for empirical analysis by considering the studies (Akhayere et al., 2023; Ali et al., 2023; Depren et al., 2023; Kartal et al., 2023d).

2.2. Empirical Approach

The first and second steps are to analyze the descriptive statistics of the dataset for the variables as well as correlations between the variables. The third step is to test the nonlinearity of the variables by using the BDS test (Broock et al., 1996). The fourth step is to investigate the effects of GPR on sectoral CO_2 emissions by performing the QQ method (Sim & Zhou, 2015). The fifth step is to apply the GQ approach to investigate the causal effect of GPR on sectoral CO_2 emissions (Troster, 2018). The last step is to perform the QR model for the robustness of the QQ results (Koenker, 2005). More comprehensive explanations for the empirical methods used in the study can be obtained from the aforementioned sources. Fig. 1 demonstrates the empirical approach applied in this study.

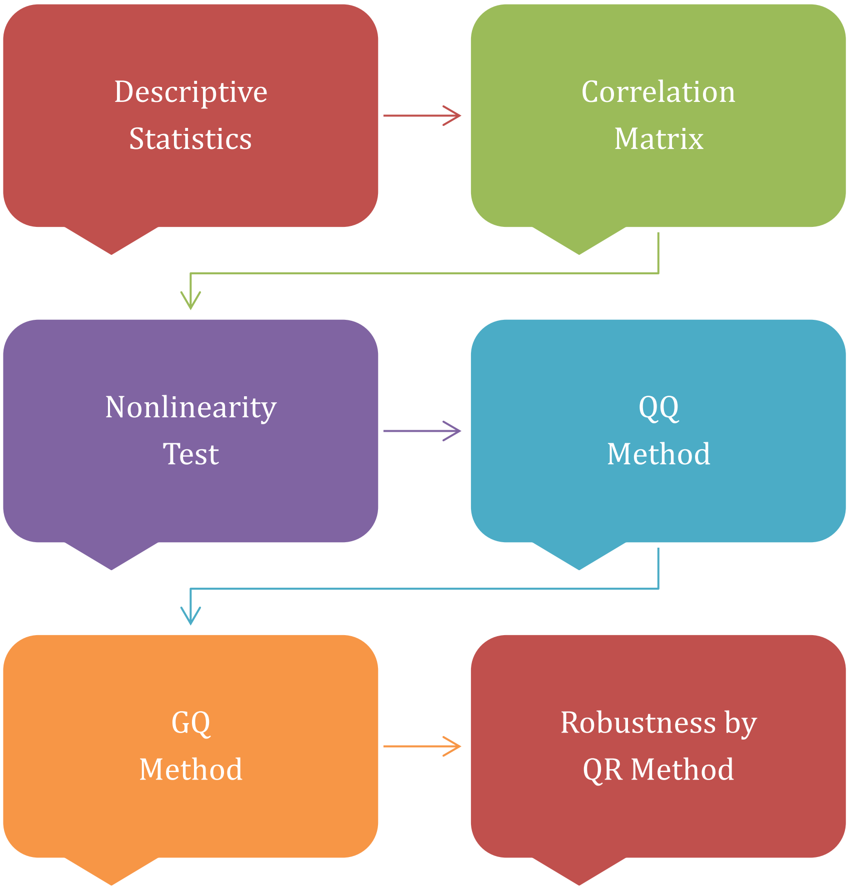


Figure 1. Empirical Approach

3. EMPIRICAL RESULTS AND DISCUSSION

3.1. Descriptive Statistics

Table 1 reports the descriptive statistics of the variables.

Table 1. Descriptive Statistics

Variable	Mean	Minimum	Maximum	Standard Deviation	JB Probability
$DACO_2$	0.04	0.01	0.07	0.01	0.0000
$IACO_2$	0.02	0.00	0.05	0.01	0.0000
$TRCO_2$	0.63	0.19	0.70	0.09	0.0000
$INCO_2$	0.80	0.57	1.17	0.09	0.0000
$POCO_2$	2.88	1.48	4.54	0.67	0.0000
$RECO_2$	0.48	0.10	1.23	0.29	0.0000
RGPR	0.05	0.01	0.30	0.05	0.0000

According to Table 1, $POCO_2$ has the highest mean value and standard deviation among all variables. Following it, $RECO_2$, $INCO_2$, and $TRCO_2$ have the highest mean values and standard deviations. Also, RGPR, $DACO_2$, and $IACO_2$ have the lowest standard deviations with regard to other variables. Moreover, all the variables have a non-normal distribution based on JB values.

3.2. Correlation Matrix

Table 2 reports the correlation coefficients between the variables.

Table 2. Correlation Matrix

	$DACO_2$	$IACO_2$	$TRCO_2$	$INCO_2$	$POCO_2$	$RECO_2$	RGPR
$DACO_2$	1.00						
$IACO_2$	0.21	1.00					
$TRCO_2$	0.14	-0.17	1.00				
$INCO_2$	0.23	-0.14	0.61	1.00			
$POCO_2$	0.12	-0.20	0.76	0.75	1.00		
$RECO_2$	-0.01	0.03	-0.02	0.07	0.10	1.00	
RGPR	-0.00	-0.00	0.06	0.08	0.07	0.03	1.00

According to Table 2, RGPR has a negative correlation with $DACO_2$ and $IACO_2$. On the other hand, RGPR has a positive correlation with $TRCO_2$, $INCO_2$, $POCO_2$, and $RECO_2$.

3.3. Linearity Test

Table 3 reports the results of the nonlinearity examination.

Table 3. Linearity Test

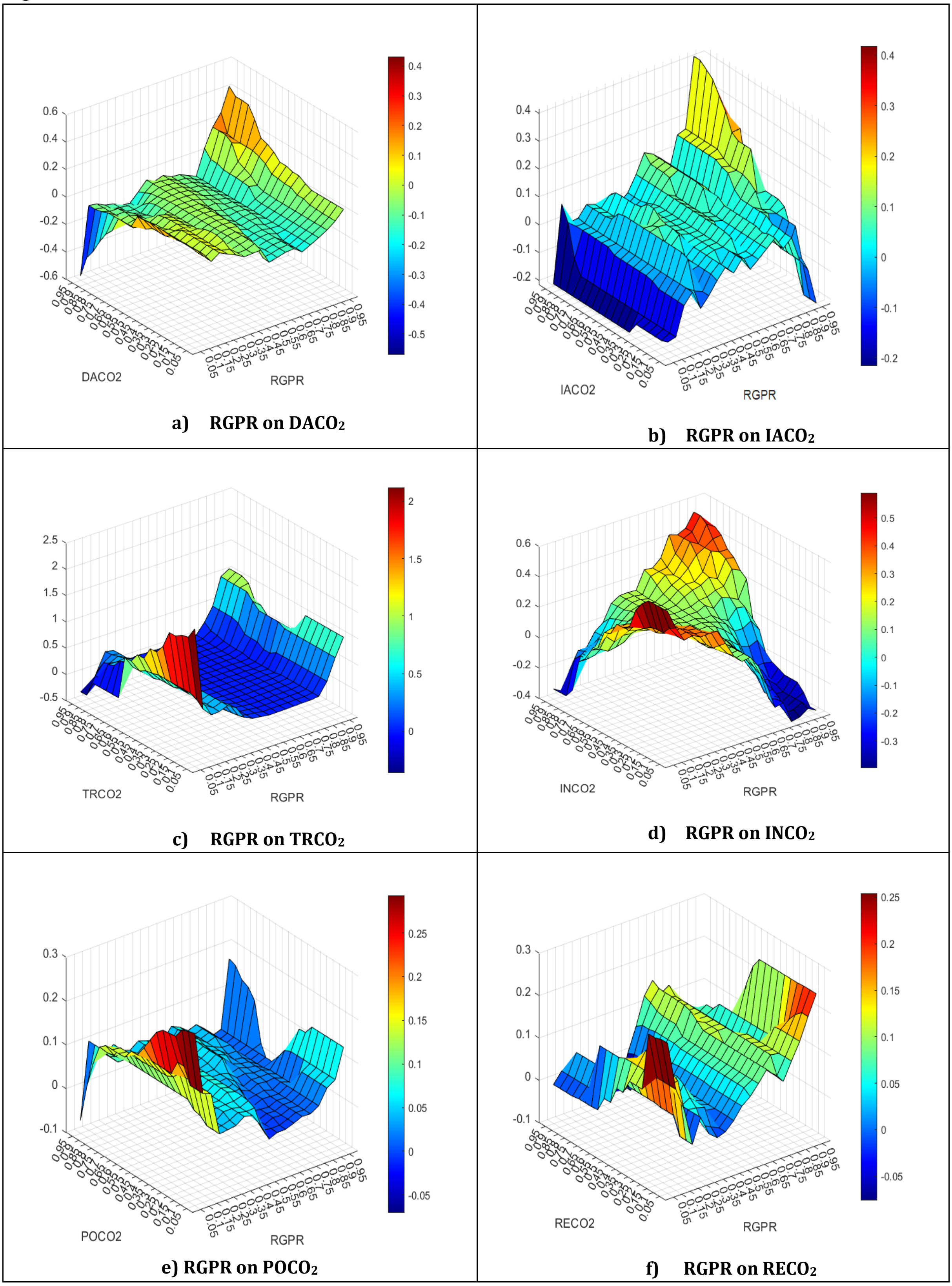
Variable	Dimensions					Results
	2	3	4	5	6	
$DACO_2$	0.000	0.000	0.000	0.000	0.000	Nonlinear
$IACO_2$	0.000	0.000	0.000	0.000	0.000	Nonlinear
$TRCO_2$	0.000	0.000	0.000	0.000	0.000	Nonlinear
$INCO_2$	0.019	0.000	0.015	0.295	0.692	Nonlinear
$POCO_2$	0.000	0.000	0.000	0.002	0.009	Nonlinear
$RECO_2$	0.000	0.000	0.000	0.000	0.000	Nonlinear
RGPR	0.000	0.000	0.000	0.000	0.000	Nonlinear

Notes: Values indicate p-values

According to Table 3, all variables generally have p-values that are lower than 0.05. These values imply that all these variables have a nonlinear structure. By considering the non-normal distribution and nonlinear structure of variables, the usage of nonlinear methods can be much more appropriate. Accordingly, quantile-based nonlinear methods (e.g., QQ, GQ, and QR) are applied for empirical analysis, respectively.

3.4. QQ Results

Fig. 2 demonstrates the QQ results.



a) RGPR on $DACO_2$

b) RGPR on $IACO_2$

c) RGPR on $TRCO_2$

d) RGPR on $INCO_2$

e) RGPR on $POCO_2$

f) RGPR on $RECO_2$

Figure 2. The QQ Results

In Fig. 2a, RGPR has a decreasing effect on $DACO_2$ at lower and middle quantiles of RGPR and all of $DACO_2$. On the other hand, at higher quantiles, RGPR has an increasing effect on $DACO_2$. This shows that although GPR has a curbing effect on the domestic aviation sector, however, it causes an increase after GPR reaches higher levels.

In Fig. 2b, RGPR has a decreasing effect on $IACO_2$ at lower quantiles of RGPR and all of $DACO_2$. However, at middle and higher quantiles, RGPR has an increasing effect on $IACO_2$. This shows that while a low-level GPR declines CO_2 emissions in the international aviation sector, however, it causes a stimulating effect when the GPR exceeds the mean level.

In Fig. 2c and Fig. 2e, RGPR has a relatively similar effect on CO_2 emissions in both transport and power sectors. Although middle-level GPR has a limiting effect, higher levels of GPR have an increasing effect.

In Fig. 2d, RGPR has a mixed effect on CO_2 emissions in the industry sector. RGPR has a decreasing effect on $INCO_2$ at higher quantiles of RGPR and lower quantiles of $INCO_2$. Also, there is a limiting effect on $INCO_2$ at lower quantiles of RGPR and higher quantiles of $INCO_2$. In all other quantiles, RGPR has an increasing effect on $INCO_2$.

In Fig. 2f, while RGPR has a declining effect on CO_2 emissions in the residential sector, however, an increase in it causes a supporting effect on causing much more CO_2 emissions.

3.5. GQ Results

Table 4 reports the GQ results.

Table 4. GQ Results

Path	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
RGPR⇨$DACO_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RGPR⇨$IACO_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RGPR⇨$TRCO_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RGPR⇨$INCO_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RGPR⇨$POCO_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RGPR⇨$RECO_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Numbers represent p-values.

According to Table 4, there are generally causal effects from RGPR to sectoral CO_2 emissions in Russia. However, as it can be seen, the causal effects do not exist at some quantiles. In other words, there are no causal effects from RGPR to both $TRCO_2$ and $INCO_2$ at 0.55 quantile. Also, there are no causal effects from RGPR to other sectoral CO_2 emissions at 0.50 quantile. Thus, the causal effects of RGPR on sectoral CO_2 emissions vary based on quantiles.

3.6. Robustness Check

Finally, the QR method is performed for robustness. The detailed results for the comparison of both QQ and QR methods are presented in the Annex. Also, Table 5 summarizes the comparison of both QQ and QR methods.

Table 5. Robustness Summary between QQ & QR Methods

Variable Pairs	Correlation (%)
RGPR & $DACO_2$	88.28
RGPR & $IACO_2$	92.03
RGPR & $TRCO_2$	76.73
RGPR & $INCO_2$	90.50
RGPR & $POCO_2$	93.17
RGPR & $RECO_2$	89.80

As Fig. 3 represents and Table 5 summarizes, the correlation between QQ and QR methods is higher than 70%. So, the results of the QQ and QR methods have consistency, and the robustness of QQ results is proved by the QR method.

4. CONCLUSION AND POLICY CAVEATS

In recent times, environmental issues along with geopolitical concerns have been highly attractive for all economic parties, especially for those, which are in Europe areas. That is why there is an ongoing Russia-Ukraine conflict, which has been causing a high level of geopolitical risk, as well as an energy crisis. This condition forces both Russia and EU countries to take various measures and such measures have been effective on carbon neutrality of countries by affecting environmental degradation performance. By considering these points as well as focusing on the literature on mainly EU countries and ignorance of Russia, this study chooses to handle Russia for empirical investigation about the function of geopolitical risk on carbon neutrality. In this context, Russia's sectoral CO_2 emissions are investigated by relying on geopolitical risk and using high-frequency daily data from January 2, 2019, to June 30, 2023.

The quantile-based methods reveal that increasing GPR generally stimulates sectoral CO_2 emissions except in the industry sector; the effects of GPR vary based on sectors and quantiles; and the results are robust on the alternative method. The results of this research are generally similar to the literature (i.e., increasing effect of GPR on CO_2 emissions) (e.g., Ulussever et al., 2023b). However, because Russia is a country, that is sanctioned, and has begun to use much more fossil fuel sources in the domestic energy market, it is natural that increasing GPR has a mainly stimulating effect on sectoral CO_2 emissions in Russia. This is the further developing finding of this study on the current literature.

Based on results collected from quantile-based methods, various policy caveats can be argued for Russia's case. In summary, GPR mainly stimulates all sectoral CO_2 emissions except for in the industry sector at higher quantiles. This finding reveals that increasing GPR has a stimulating effect on CO_2 emissions in all sectors except for the industry sector, which harms the carbon neutrality target of Russia. So, Russia has some options here. Russia should work on decreasing the current geopolitical risk that it has faced. Hence, it would decrease the increasing effect of geopolitical risk on CO_2 emissions. Also, it would benefit from the getting of using more fossil fuel sources in the domestic energy market and having the opportunity to focus on more clean energy sources. In this way, Russia may go on with dealing with the carbon neutrality target by declining CO_2 emissions through getting of negative effects of geopolitical risk.

Also, this study defines that the effects of GPR on sectoral CO_2 emissions vary based on quantiles. Besides, the causal effects of GPR on sectoral CO_2 emissions change for each indicator and quantile. Hence, Russia should take into account these changing effects in case structuring policy formulation for both geopolitical risk and carbon neutrality.

Furthermore, Russian policymakers should deal highly with the clean energy transition by stimulating both renewable and nuclear energy and declining fossil fuel-based sources in energy generation. Hence, carbon neutrality can be more easily provided by contributing effect of cleaner energy by curbing the adverse effect of fossil sources.

This study focuses on Russia, which differs from many studies in the literature. On the other hand, many recent studies have focused on EU countries. By considering two different sides of the literature, new studies can consider both Russia and EU countries for a simultaneous examination. Also, new research can consider other factors than GPR that are not included in this study. Finally, although this study applies a variety of novel quantile-based time series methods, there are still some other novel methods. So, new studies can evaluate to consider applying such methods for further empirical investigation.

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Appendix A

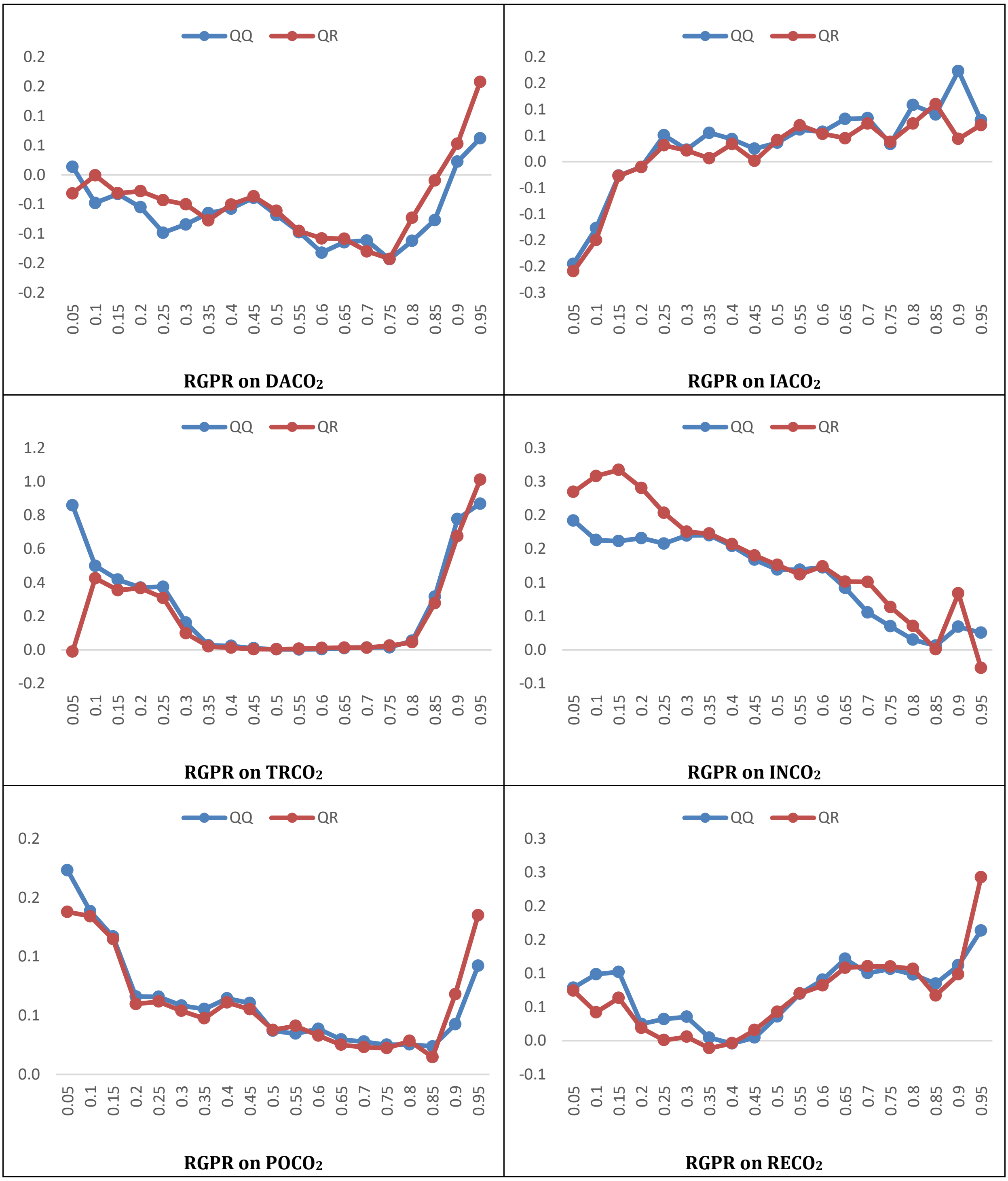

Figure A1. Robustness Details between QQ & QR Methods