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Assessing the Impact of Geopolitical Risk on Environmental Degradation in G7 Countries: A Quantile-on-Quantile Regression Approach

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Abstract: Considering the recent adverse developments, studies have focused on the environmental degradation of countries. In this context, various indicators for the environment as well as explanatory variables have been used. In line with the increasing geopolitical risk (GPR) in recent times, the study focuses on investigating the impact of GPR on the environment for G7 countries, which are the leading economies in the world. In doing so, the study considers carbon dioxide (CO_2) emissions and ecological footprint (EF) as the environmental indicators; and performs quantile-on-quantile regression (QQ) as the fundamental model, which investigates the relationship between two variables across quantiles (i.e., levels); applies quantile regression (QR) for robustness; and uses using monthly data between 1985 and 2022. The study proves that (i) GPR generally decreases CO_2 emissions at higher quantiles, whereas it causes an increasing impact at lower quantiles; (ii) GPR mainly curbs EF at higher levels, whereas it causes a stimulating impact at lower levels; (iii) the power of the impact of GPR differentiates a bit according to quantiles, indicators, and countries; (iv) the alternative method mostly validates the robustness of the results. Thus, the study implies that GPR has a stimulating impact on environmental degradation at the beginning (i.e., lower quantiles) by causing much more consumption and short-term-based decisions, whereas it causes a decline at the last (i.e., higher quantiles) through making consumption more responsible and decisions with more long-term-based perspective. So, GPR is an important predictor of the environment and has a critical impact on environmental degradation. Accordingly, policymakers have to consider the quantile, country, and environmental indicator-based differentiation impact of GPR on the environment in designing environmental policies. In this way, it is possible for the countries to achieve sustainable development goals by ensuring environmental degradation.

Keywords: Geopolitical risk; Environmental degradation; G7 countries; Quantile regression methods

JEL Classification = C32; N50; O13

1 Introduction

The world has been facing critical problems, such as climate change and global warming, which have resulted from the degradation of environmental quality [1, 2]. Because negative impacts on humankind have been occurring, all countries and societies have been much more interested in environmental degradation [3, 4]. In line with such an increasing interest, research into environmental degradation has been progressing. In this context, various studies have explored the drivers of environmental degradation.

In analyzing the causes of environmental degradation, previous studies used mainly CO_2 emissions as an environmental proxy (e.g., Wang et al. [5]). Differently, many newer studies have used the EF as an environmental proxy (e.g., Pata et al. [6]) because CO_2 emissions focus on only air pollution and do not consider pollution in other areas, such as water or soil. Hence, the literature includes various studies that use either CO_2 emissions or EF to examine the progress of the environment over the years.

Also, a lot of different indicators have been considered to investigate the impact on the environment. Previous studies focus on mainly economic growth and energy consumption (e.g., Kartal et al. [7]), whereas much newer studies have considered more social indicators, such as environmental tax, industrialization, urbanization, and trade openness (e.g., Ali et al. [8] and Depren et al. [9]). Hence, the literature has been evolving in terms of factors that have been affecting the environment.

On the other hand, there have been recent emerging issues, such as the energy crisis that has resulted from the conflict between Russia and Ukraine. It causes an important increase in GPR, which may be expected to have a role in the progress of environmental quality. In the case of increasing GPR, a change in various factors, such as energy consumption, consumer consumption, and investments in energy generation sources, can be expected [10]. So, while GPR increases, it can be pre-expected that some consumption preferences can be made on a short-term basis and energy use can be reliant more on fossil sources than clean sources. Also, in such an environment, where GPR increases, short-term decisions by policymakers can be preferred instead of long-term decisions. So, an increase in GPR may have an increasing impact on environmental degradation. On the other hand, if GPR continues to rise, consumers can prefer to decline their consumption, decrease energy use, and use much more clean energy instead of fossil sources. So, this can result in a decline in environmental degradation. So, GPR can have either an increasing or decreasing impact on environmental degradation.

When the literature is examined, it can be seen that some studies have considered the impact of GPR on the environment. For instance, Pata et al. [10] examine the USA case, and Ulussever et al. [11] analyze GCC countries. Even some of them [12] have examined G7 countries by applying a panel data approach. Although the countries in the G7 are developed countries, nevertheless, there are some differences between these countries because they are on different continents and have different economic, environmental, monetary, and fiscal regulations, which are required to be considered in any analysis. So, country-based differences should be considered in formulating environmental policies and empirical approaches. Hence, it can be stated that the literature has a gap from this perspective, and the study aims to close this gap.

In researching the impact of GPR on the environment, by considering the literature gap, the study focuses on G7 countries (namely, Canada-CAN, Germany-DEU, France-FRA, the United Kingdom-GBR, Italy-ITA, Japan-JPN, and the USA) as a single case rather than a panel. Hence, this study considers country-based differences in the empirical examination by applying time-series analysis methods. In doing so, the study uses CO_2 emissions as the base environmental indicator, considers EF as the alternative environmental indicator, applies the QQ method as the main model, and performs the QR method for robustness. The QQ method enables researchers to investigate the relationship between two variables across quantiles (i.e., levels) by focusing on each country and considering potential differences between countries. Also, the QQ method considers the nonlinear characteristics of the variables, which is an important factor in the selection of this method. Hence, the study presents the critical impact of GPR on the environment in each G7 country, while quantile, indicator, and country-based impacts vary. Thus, the research provides the main contributions to the literature as follows: (i) the study shows that GPR slows down environmental damage, measured by CO_2 emissions and EF, at higher quantiles but speeds it up at lower quantiles; (ii) GPR's effect on the environment changes depending on quantiles, indicators, and country.

Following the IMRAD approach, Section 2 explains the methods; Section 3 presents the results; and Section 4 concludes.

2 Methods

2.1 Data

The study examines the impact of GPR on environmental degradation, which is mediated by CO_2 emissions and EF. Data on CO_2 emissions is gathered from EI [13], data on EF is obtained from GFN [14], and data for GPR is collected from www.matteoiacoviello.com [15].

Data on GPR is on a monthly basis, whereas data on CO_2 and EF is on an annual basis. So, these differences require an adjustment to make them at the same frequency. For this reason, the study transforms the annual data into monthly data by performing the quadratic sum method, as in line with recent research (e.g., Ulussever et al. [11]; Bhattacharya et al. [16]; Sharif et al. [17]). This study applies the quadratic sum method instead of other transformation approaches because it provides much more reliable results in data transformation. Also, the study transforms the dataset into a return series by using a logarithmic difference approach, as consistent with the recent studies (e.g., Ayhan et al. [18]; Kartal et al. [19]). Hence, the study uses monthly data between 1985/2 and 2022/12, which is the most recent available dataset.

Table 1 summarizes the details of the variables.

Table 1. Variables

Type	Variable	Explanation	Data Source
Dependent	CO_2	Carbon Dioxide Emissions	EI [13]
	EF	Ecological Footprint	GFN [14]
Independent	GPR	Geopolitical Risk	www.matteoiacoviello.com [15]

2.2 Empirical Approach

Figure 1 demonstrates the empirical approach used in the study.

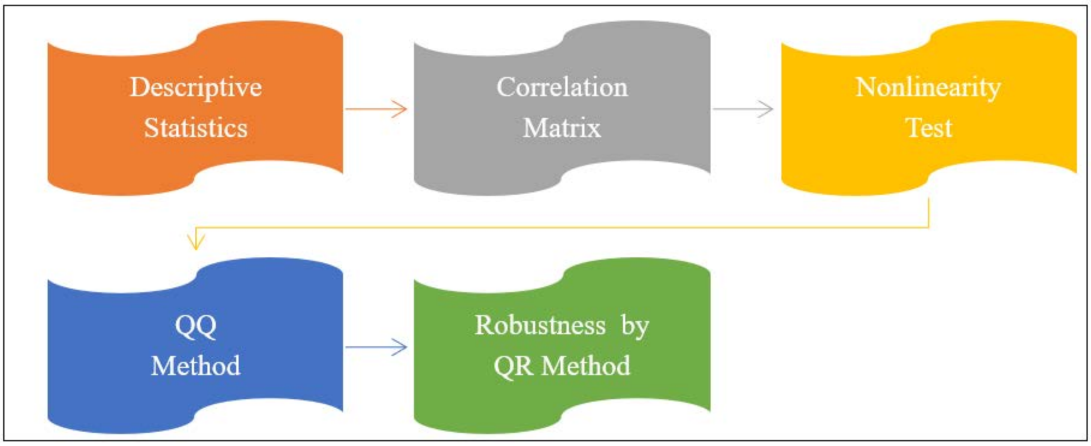


Figure 1. Methodological approach

Firstly, the fundamental statistics (i.e., descriptive statistics) of the variables are analyzed. Secondly, correlations between the variables are uncovered. Thirdly, the nonlinearity characteristics of the variables are investigated by using the BDS test [20]. Fourthly, the QQ method [21] is used to analyze the quantile-based impact of GPR on environmental indicators. Differentiating from traditional models, the QQ method investigates the relationship between two variables across quantiles (i.e., levels) of both variables. In this context, CO_2 emissions are used as the main environmental indicator, and EF is used as the alternative indicator for robustness. Lastly, the robustness of the results is checked. So, in addition to consideration of an alternative environmental indicator (i.e., EF), the QR method [22] is also applied as an alternative method.

3 Results

3.1 Descriptive Statistics

As the leading step, Table 2 presents the descriptive statistics.

There is a higher volatility in CO_2 emissions, followed by EF and GPR, in all countries. Also, according to JB probability values, most of the variables have a nonnormal distribution, whereas CO_2 and EF in only DEU have a normal distribution. So, the results of descriptive statistics show that there are significant variations and nonnormalities in the variables. This requires consideration of a nonlinear approach in the empirical investigation.

3.2 Correlation Results

Secondly, Table 3 presents the correlation results.

GPR has a negative relationship with CO_2 emissions in all countries, except for FRA and GBR. Also, GPR has a negative relationship with EF in all countries except for CAN, GBR, and JPN. Moreover, the power of the correlation between the variables changes across countries. So, this implies that the impact of GPR on both CO_2 emissions and EF can have a varying structure across countries. Hence, this requires consideration of country-based examinations in the empirical investigation.

3.3 Nonlinearity Results

Thirdly, Table 4 presents the results of the nonlinearity examination.

Based on Table 4, all variables have a nonlinear structure across all dimensions in all countries, with no exception. So, the results of the BDS test show that no variables have a linear structure. This determination also requires consideration of a nonlinear approach in the empirical investigation.

Table 2. Descriptive statistics

Country	Variable	Mean	Max.	Min.	SD	Skewness	Kurtosis	JB	JB Prob.
	CO_2	42.49	48.09	32.70	4.50	-0.70	2.15	50.62	0.0000
CAN	EF	22.70	26.89	18.44	2.16	-0.29	2.08	22.38	0.0000
	GPR	0.23	1.72	0.06	0.16	4.19	31.17	16,379.79	0.0000
	CO_2	70.29	87.47	49.95	9.31	-0.04	2.54	4.17	0.1243
DEU	EF	37.84	45.02	29.82	3.50	-0.10	2.71	2.35	0.3094
	GPR	0.39	2.72	0.08	0.28	3.68	24.46	9,760.85	0.0000
	CO_2	29.25	32.72	20.63	3.07	-1.08	3.21	89.26	0.0000
FRA	EF	27.84	31.15	22.23	2.15	-0.67	2.79	34.41	0.0000
	GPR	0.53	2.80	0.14	0.32	2.93	15.30	3,521.29	0.0000
	CO_2	43.53	50.57	26.27	6.81	-1.16	3.02	102.84	0.0000
GBR	EF	26.14	31.34	19.16	2.97	-0.48	2.64	19.91	0.0000
	GPR	0.02	0.02	0.02	0.00	0.69	2.73	37.04	0.0000
	CO_2	32.51	39.31	23.59	4.03	-0.22	2.14	17.51	0.0002
ITA	EF	24.35	28.75	18.67	2.82	-0.15	1.96	22.30	0.0000
	GPR	0.16	1.44	0.03	0.13	4.34	33.00	18,484.16	0.0000
	CO_2	96.76	109.83	76.12	8.72	-0.78	2.79	46.41	0.0000
JPN	EF	50.74	58.42	39.72	4.82	-0.38	2.25	21.44	0.0000
	GPR	0.22	1.00	0.03	0.14	1.94	7.80	722.88	0.0000
	CO_2	437.17	491.62	368.47	31.98	-0.02	2.13	14.51	0.0007
USA	EF	226.36	260.99	196.23	18.17	0.40	1.98	31.54	0.0000
	GPR	2.33	13.23	0.75	1.26	4.42	31.89	17,302.31	0.0000

Note: Min: Minimum; Max: Maximum; SD: Standard Deviation; JB: Jarque-Bera. Units for CO_2 and EF are million tons and million global hectares, in order.

Table 3. Correlation results

Country	Variable	CO_2	EF	GPR
	CO_2	1.00		
CAN	EF	0.36	1.00	
	GPR	-0.03	0.03	1.00
	CO_2	1.00		
DEU	EF	0.75	1.00	
	GPR	-0.04	-0.09	1.00
	CO_2	1.00		
FRA	EF	0.60	1.00	
	GPR	0.01	-0.04	1.00
	CO_2	1.00		
GBR	EF	0.49	1.00	
	GPR	0.02	0.02	1.00
	CO_2	1.00		
ITA	EF	0.74	1.00	
	GPR	-0.06	-0.03	1.00
	CO_2	1.00		
JPN	EF	0.81	1.00	
	GPR	-0.01	0.00	1.00
	CO_2	1.00		
USA	EF	0.73	1.00	
	GPR	3	2	1.00

In the case of the overall evaluation of preliminary statistics, most of the variables have a nonnormal distribution, whereas all variables have a nonlinear structure. Hence, applying nonlinear methods is much more appropriate. Accordingly, the study uses the novel QQ method as the main model to investigate the impact of GPR on the environment across quantiles, while the QR method is used for robustness.

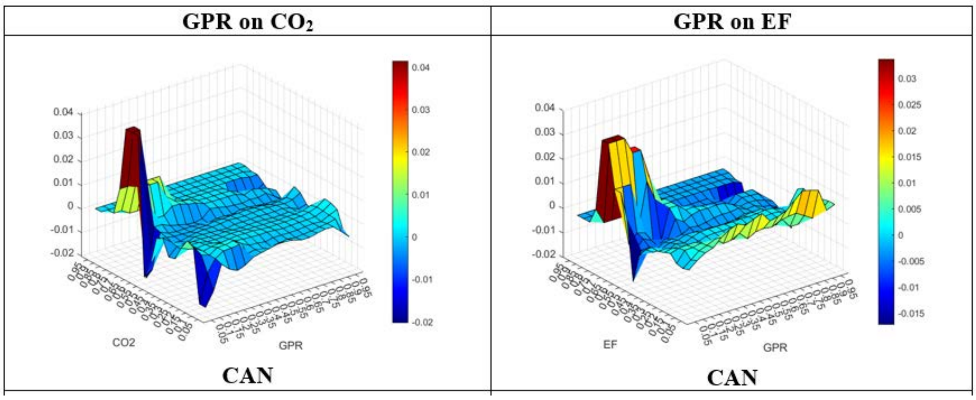
Table 4. Nonlinearity results

Country	Variable	D2	D3	D4	D5	D6	Result
	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000	NL
CAN	EF	0.0000	0.0000	0.0000	0.0000	0.0000	NL
	GPR	0.0000	0.0000	0.0000	0.0000	0.0000	NL
	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000	NL
DEU	EF	0.0000	0.0000	0.0000	0.0000	0.0000	NL
	GPR	0.0003	0.0008	0.0006	0.0005	0.0004	NL
	CO_2	0.0000	0.0000		0.0000		
FRA	EF	0.0000	0.0000	0.0000	0.0000	0.0000	NL
	GPR	0.0027	0.0000	0.0000	0.0000	0.0000	NL
	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000	NL
GBR	EF	0.0000	0.0000	0.0000	0.0000	0.0000	NL
	GPR	0.0015	0.0000	0.0000	0.0000	0.0000	NL
	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000	NL
ITA	EF	0.0000	0.0000	0.0000	0.0000	0.0000	NL
	GPR	0.0000	0.0000	0.0000	0.0000	0.0000	NL
	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000	NL
JPN	EF	0.0000	0.0000	0.0000	0.0000	0.0000	NL
	GPR	0.0000	0.0000	0.0000	0.0000	0.0002	NL
	CO_2	0.0000	0.0000	0.0000	0.0000	0.0000	NL
USA	EF	0.0000	0.0000	0.0000	0.0000	0.0000	NL
	GPR	0.0003	0.0000	0.0000	0.0000	0.0000	NL

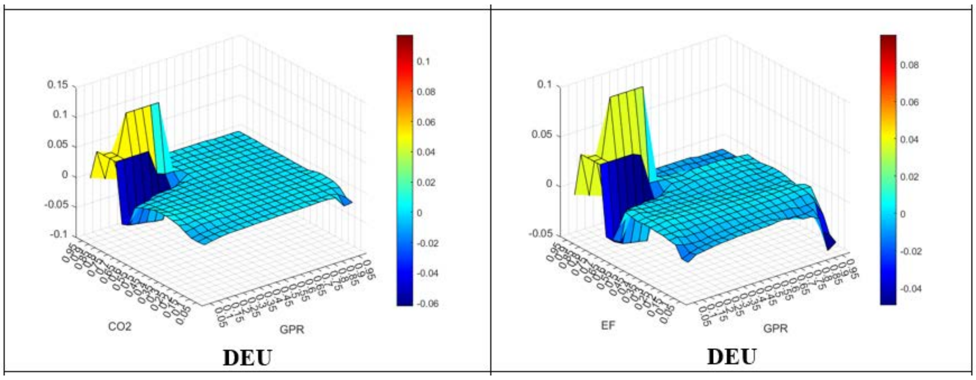
Note: Values indicate probability values. D and NL denote the dimension and nonlinear, in order.

3.4 GPR Impact on Environmental Degradation

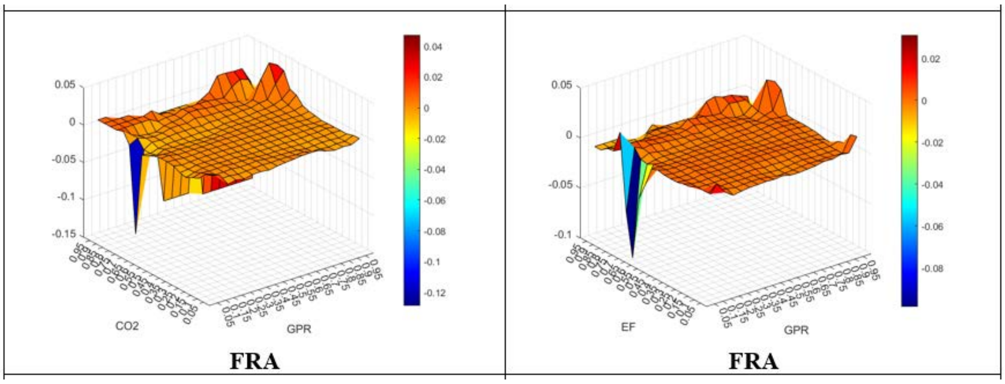
Additionally, the study used the QQ approach to examine the influence of GPR on the environment at different quantiles. Figure 2 displays the QQ results.



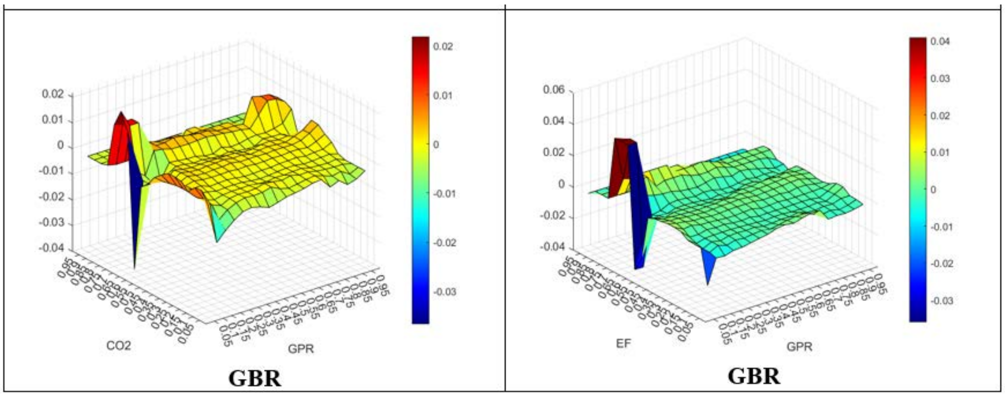
(a)



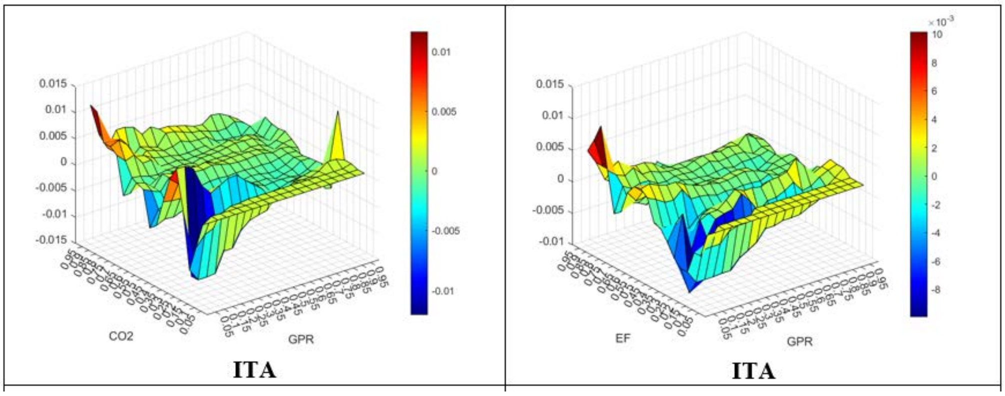
(b)


CO2
GPR
FRA
EF
GPR
FRA

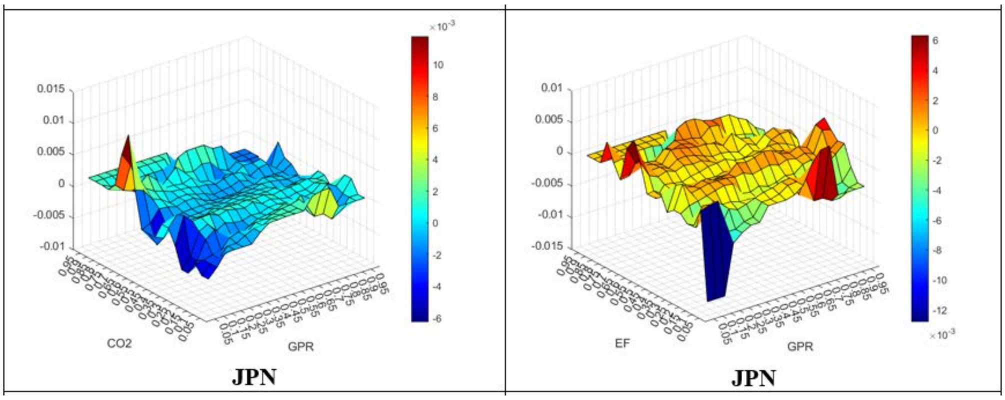
(c)


CO2
GPR
GBR
EF
GPR
GBR

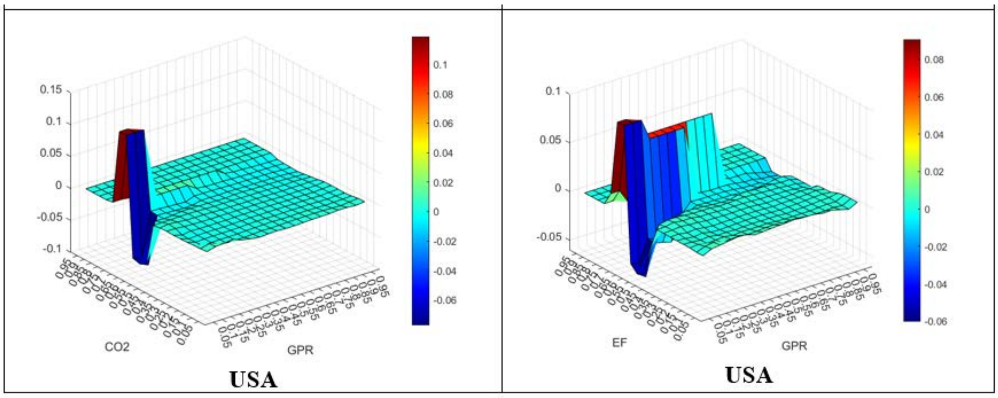
(d)


CO2
GPR
ITA
EF
GPR
ITA

(e)


CO2
GPR
JPN
EF
GPR
JPN

(f)



(g)

Figure 2. QQ results for GPR impact on environmental degradation

In CAN, GPR has an increasing impact on CO_2 emissions at lower (0.05-0.35) quantiles. However, the impact becomes almost insignificant across middle quantiles (0.40-0.70) and turns out to be decreasing at higher quantiles (0.75-0.95).

In DEU, GPR has a stimulating impact on CO_2 emissions at lower (0.05-0.35) quantiles. But the impact becomes almost insignificant across middle quantiles (0.40-0.85) and turns to be curbing one at higher quantiles (0.90-0.95).

In FRA, GPR has an increasing impact on CO_2 emissions at lower (0.05-0.25) quantiles. However, the impact turns out to be decreasing across the remaining quantiles (0.30-0.95).

In GBR, GPR has an increasing impact on CO_2 emissions at lower (0.05-0.10) quantiles. But the impact becomes declining across all quantiles (0.15-0.95).

In ITA, GPR has a stimulating impact on CO_2 emissions at lower (0.05-0.10) quantiles. However, the impact becomes almost insignificant across some lower quantiles (0.15-0.25) and turns out to be increasing once again at higher quantiles (0.30-0.90), except for 0.95.

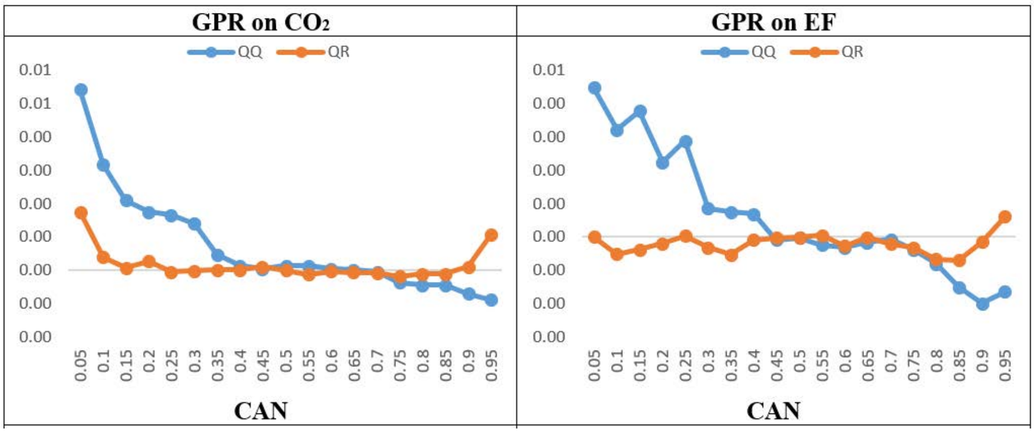
In JPN, GPR has an increasing impact on CO_2 emissions at the lower and middle (0.05-0.70) quantiles, whereas the impact becomes lessened across the remaining quantiles (0.75-0.95).

In the USA, GPR has a stimulating impact on CO_2 emissions at lower and middle (0.05-0.65) quantiles, whereas the impact becomes curbing across all remaining quantiles (0.70-0.95).

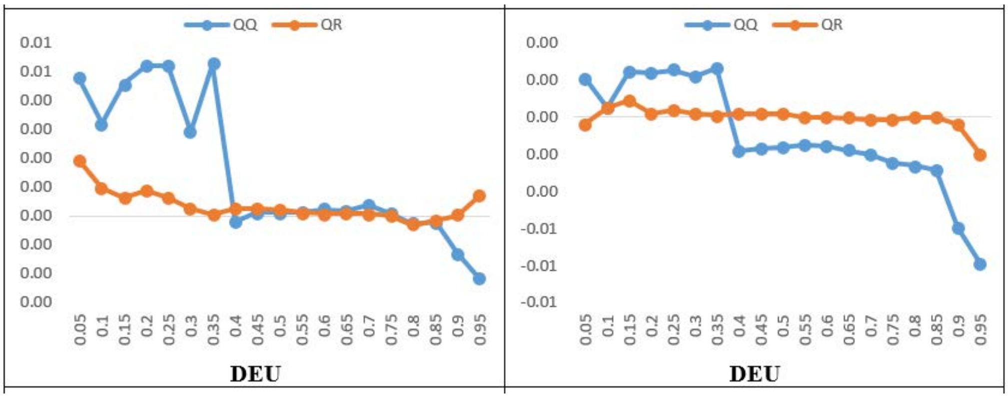
When the impacts of GPR on the EF are analyzed, even though there are a few variations over quantiles, the impact of the EF is identical with CO_2 emissions over quantiles that are seen in the right panel of Figure 2. Hence, it is possible to state that the impacts of GPR on the environment are highly consistent according to alternative indicators (i.e., CO_2 emissions and EF).

3.5 Robustness

As the final step, while the study uses EF as an alternative proxy for the environment, the study also applies the QR method to check the robustness of the empirical method. The QR results are demonstrated in Figure 3.



(a)


QQ
QR
DEU
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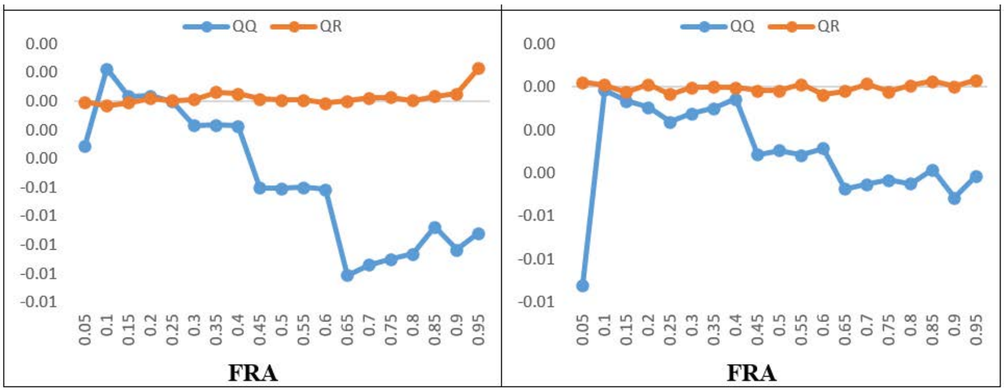
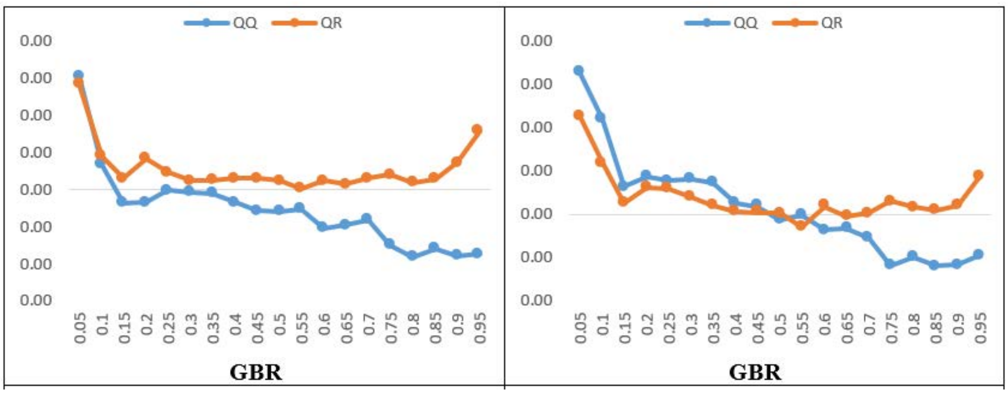
QR
DEU

(b)


QQ
QR
FRA
QQ
QR
FRA

(c)


QQ
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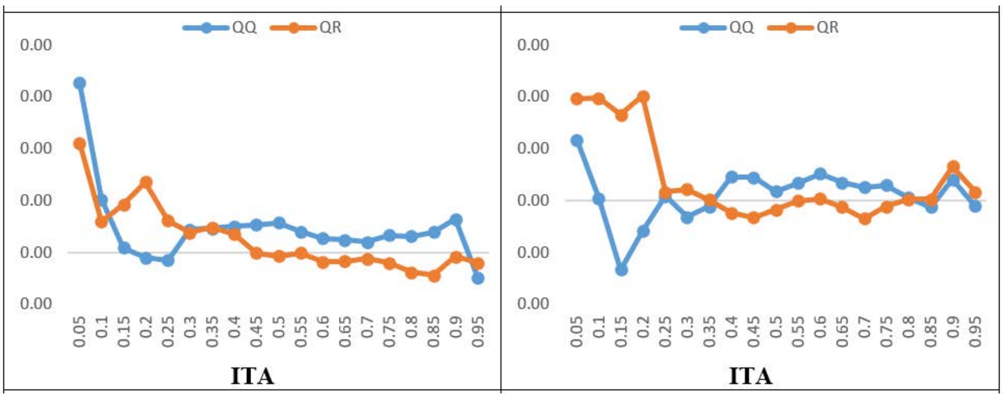
QR
GBR

(d)


QQ
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ITA
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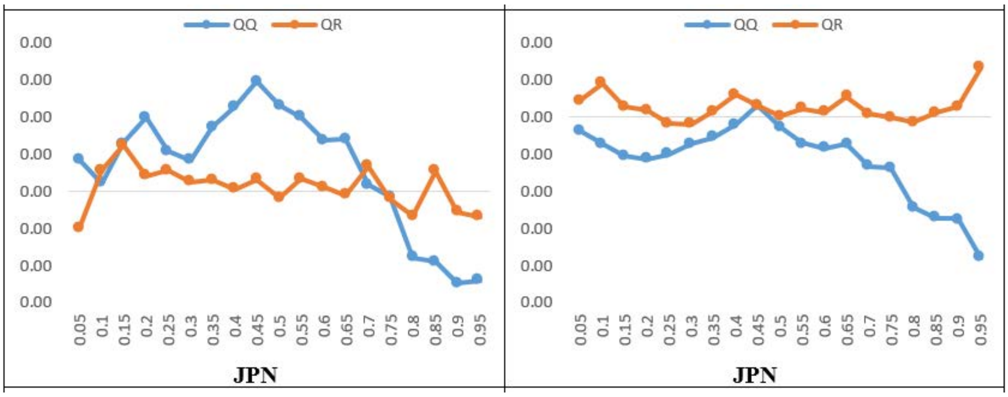
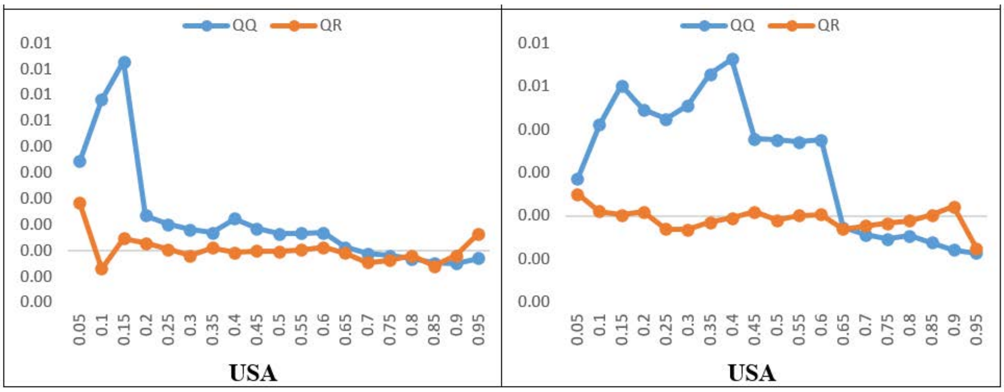
ITA

(e)



(f)



(g)

Figure 3. QQ and QR comparison for impact of GPR on environmental degradation

As presented, there are a few differences across some quantiles between the QQ and QR methods. Except for these, the results of both QQ and QR methods are highly identical. So, it can be stated that the results are mainly robust, and GPR is a critical factor for the environmental degradation that is proxied by CO_2 emissions and EF. Thus, various policy options can be argued by relying on the results obtained.

4 Conclusion

The interest of countries and societies in environmental degradation has been progressing day by day due to the negative impacts on humankind. Accordingly, efforts to prevent such negative progress have been increasing. So, various factors have been considered by scholars and policymakers. Because there is a recent energy crisis that results from geopolitical risk, it is critical to consider the impact of GPR on the environment. In line with these, the study aims to investigate the impact of GPR on environmental degradation in G7 countries, which are leading economies in the world. In this context, the study considers CO_2 emissions as the main environmental indicator, uses EF as the robust indicator, applies the QQ approach as the fundamental approach, and performs the QR approach for the robustness check by using monthly data between 1985/2 and 2022/12.

The research outcomes present that GPR decreases environmental degradation at higher quantiles, whereas it causes an increasing impact at lower quantiles. Besides, the power of the impact of GPR differs based on quantiles, indicators, and countries. Moreover, the alternative method mostly validates the robustness of the results. The research proves that GPR has a nonlinear relationship with environmental degradation. Also, the impact of GPR on environmental degradation varies according to quantiles, countries, and indicators. In the case of the overall evaluation of the results with regard to the literature, the results are generally consistent with present knowledge, but the research extends the knowledge by presenting more details across quantiles.

By considering the outcomes obtained, the study discusses policy options. Accordingly, policymakers in G7 countries should take into account the nonlinear structure of GPR in terms of environmental degradation over the years. If they rely on a linear approach in policy formulation without considering nonlinearity, they can go the wrong way because this study proves nonlinear results. In such a case, while policymakers can try to benefit from GPR, unfortunately, they cannot achieve this. Even a reverse impact of GPR on environmental degradation can be seen due to the wrong approach of policymakers.

Also, considering that GPR has an increasing impact on environmental degradation at lower quantiles, which implies a stimulating impact at the beginning of increases, policymakers should be careful about increasing GPR at the initial stages. In this stage, taking macro-prudential measures to prevent the increasing impact of GPR on environmental degradation is inevitable.

Besides, a further increase in GPR turns into a curbing one at much higher quantiles. Hence, much more increasing GPR has a mainly declining impact on environmental degradation. Hence, policymakers in G7 countries should benefit from such periods to use them as leverage to put the structural reforms into effect.

Moreover, because the impact of GPR on environmental degradation varies across quantiles, policymakers should take into account nonlinear methods in structuring eco-friendly policies. If they prefer to follow a linear approach, the policymakers in G7 countries can't structure environmental policies most appropriately. So, they can decide on the wrong policy mix, which may cause further damage to the environment.

Although this study aims to apply a comprehensive investigation of the impact of GPR on environmental degradation (i.e., CO_2 emissions and EF), there are some limitations in nature. Firstly, the study focuses on only environmental degradation and ignores the environmental quality perspective. So, new studies can consider focusing on the environmental quality perspective by using the load capacity factor as an environmental indicator. Secondly, since the study focuses on G7 countries, new studies can examine other important countries or country groups (e.g., E7, BRICS). Thirdly, although this study uses relatively high-frequency (i.e., monthly) data, new studies can use much higher-frequency (i.e., daily or weekly) data for the empirical analysis. Fourthly, different location-based analyses (i.e., city, province, state) can be applied as well. Fifthly, new econometric methods that have been recently developed can be used in new research. Lastly, new studies can consider investigating the impact of other non-economic and non-energy factors, such as economic policy uncertainty, population, and domestic and international migration, on environmental degradation. Hence, the literature can be developed further.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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Nomenclature

BDS	Broock, Scheinkman, Dechert, and LeBaron
CO_2	Carbon Dioxide
EF	Ecological Footprint
EI	Energy Institute
GCC	Gulf Cooperation Council
GFN	Global Footprint Network
GPR	Geopolitical Risk
JB	Jarque-Bera
QQ	Quantile-on-Quantile Regression
QR	Quantile Regression
SDGs	Sustainable Development Goals
USA	United States of America