sustainability

Article

Is Geopolitical Risk Powerful Enough to Affect Carbon Dioxide Emissions? Evidence from China

Kai-Hua Wang *, Jia-Min Kan, Cui-Feng Jiang and Chi-Wei Su

School of Economics, Qingdao University, Qingdao 266100, China; kanjiamin991111@163.com (J.-M.K.); jcf1210@126.com (C.-F.J.); cwsu7137@qdu.edu.cn (C.-W.S.)
* Correspondence: wangkaihua2019@qdu.edu.cn; Tel.: +86-178-6532-1935

Abstract: Escalating geopolitical factors are closely related to climate warming, but researchers have not fully considered this. Therefore, the purpose of this study is to explore the interaction between geopolitical risk (GPR) and carbon dioxide (CO_2) in China. This paper uses the recently developed GPR index and a bootstrap Granger rolling-window estimation. Empirical results spanning different subsamples reveal a two-way causal relationship between GPR and CO_2. GPR transforms energy consumption and economic activities through trade disputes, military deployments and energy issues, which have a complex impact on CO_2 emissions. Oppositely, CO_2 emissions affect GPR through changes in international cooperation and shaping of geopolitical systems. In view of these empirical results, we put forward several policy recommendations. The Chinese government can effectively consider GPR to control CO_2 emissions by increasing green investment and signing environmental contracts. Enterprises must focus on research and development (R&D) and investment in new energy innovations. In addition, international organizations can be a useful tool for monitoring decarbonization policies and resolving conflicts between countries.

Keywords: geopolitical risk; carbon dioxide emissions; time-varying causalities; rolling-window

JEL Classification: C10; C22; R11

check for updates

Citation: Wang, K.-H.; Kan, J.-M.; Jiang, C.-F.; Su, C.-W. Is Geopolitical Risk Powerful Enough to Affect Carbon Dioxide Emissions? Evidence from China. *Sustainability* **2022**, *14*, 7867. https://doi.org/10.3390/su14137867

Academic Editor: Elena Cristina Rada

Received: 15 May 2022
Accepted: 25 June 2022
Published: 28 June 2022

1. Introduction

Climate warming is a global challenge that directly affects the ecological environment and causes serious damage to economic growth [1–3]. Carbon dioxide (CO_2) emissions are the main contributor to environmental problems and have increased rapidly in recent decades [4–7]. Given high global growth rates and expected high levels of emissions, countries are concentrating on formulating policies and taking new measures to reduce the negative impact of CO_2 emissions on the global climate [8]. A single country cannot deal with the task of carbon emission reduction alone, which means the world needs international cooperation. However, these collaborations also contain conflicts, which have profound implications for the formulation and implementation of environmental policies. In this case, geopolitical risk (GPR) is defined as a combination of military tensions, trade disputes between countries, the threat of war and the threat of terrorism [9], and has been escalating over the past few decades. Some studies have shown that GPR will affect economic growth [10], energy consumption [11], financial markets [12] and other fields [13]. It is also noted that GPR may also affect environmental indicators such as CO_2, which may lead to the loss of social welfare gains [14]. Geopolitical events such as wars and trade disputes have increased the use of fossil fuels and affected the development path of green energy, which will escalate CO_2 emissions and increase the difficulty of investment in emissions reduction. Therefore, sustainability initiatives primarily need to confront the challenges interrelated with GPR [15]. It is noticed that conflicts of interest over CO_2 emissions are turning into fierce international competition, driving GPR to change accordingly. The relationship between CO_2 and GPR is becoming more complex and diversified, which has aroused broad concern [16,17].

Recently, several mechanisms have been proposed for the effect of GPR on CO_2. The first channel is the "consumption effect". The rise of GPR could lead to increased energy consumption and military-related activities and may also slow down research and development, limiting innovation in the field of renewable energy, which in turn will escalate CO_2 emissions. The second channel is an "investment effect", which suggests that changes in GPR may promote energy independence and increase investment in green energy and related advanced technology projects, which retards CO_2 emissions [18]. Finally, GPR can hinder CO_2 emissions through a "mitigation effect". According to this effect, GPR obstructs economic growth and reduces energy consumption efficiency, and these factors will control CO_2 emissions. These indicate that GPR may increase or reduce CO_2 emissions.

Contrary to its impacts on CO_2, we propose two ways in which CO_2 can affect GPR. CO_2 emissions may affect geopolitical risks through international cooperation and competition. CO_2 emissions are increasingly affecting national competitive advantages. International cooperation and competition among large economies will make the linkages between CO_2 and GPR more complex and different. Many factors shape the current geopolitical situation, such as the dispute over carbon emission quotas, energy technology innovation in the context of low carbon and carbon markets and carbon tariffs [17]. The debate on reducing CO_2 emissions in countries is changing into intense competition, which leads to domestic and international attention on the impact of CO_2 on geopolitics [16]. This suggests that CO_2 emissions rewrite the rules of the geopolitical landscape.

Based on the above background, the uniqueness of the Chinese case prompted us to explore the interaction between GPR and CO_2. We propose the following hypothesis:

Hypothesis 1 (H1). *There is a two-way relationship between GPR and CO_2.*

Therefore, the influencing mechanisms between GPR and CO_2 are described in detail in Figure 1.

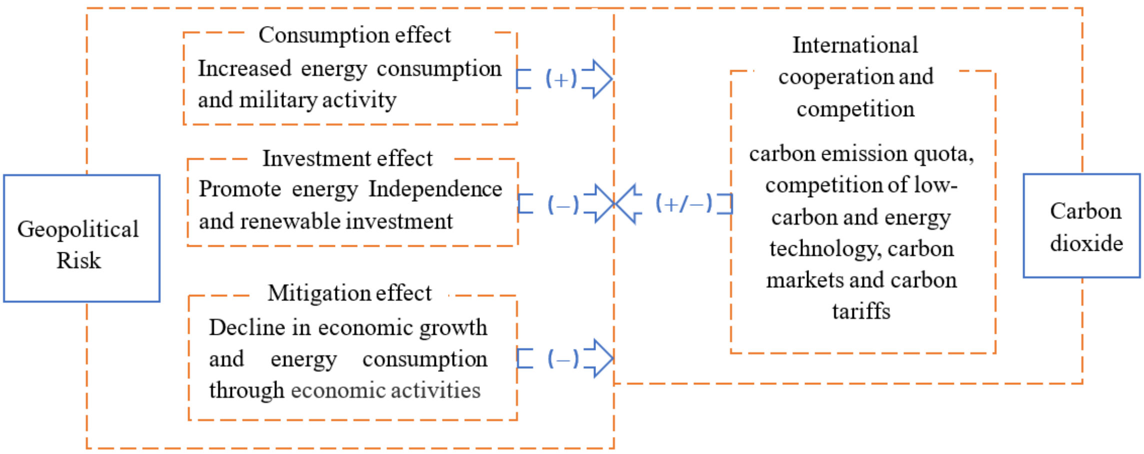

Figure 1. The two-way impact mechanism between geopolitical risk and carbon dioxide.

In order to supplement the research background, the purpose of this study is to evaluate the nexus between GPR and CO_2 emissions in China. To secure the impact of GPR on the environment, the importance of China in geopolitics and environmental governance further encourages discussion of the close links between GPR and CO_2. More specifically, first, China is the largest emitter of CO_2 [19]. Its economic growth has the characteristics of multi-pollution, high-consumption and high-emissions [20]. Second, China has set off a flurry of efforts to decrease CO_2 emissions. In September 2020, China proposed that CO_2 emissions peak and achieve carbon neutralization. A carbon market and carbon emission trading have become important tools of China's "dual carbon" policy. Last, China has complex geopolitical risks. GPR emphasizes the importance of geographic location to China because of its territorial disputes with many countries, which determines the complexity of its GPR. GPR is also related to energy security. Due to its lack of crude oil and natural gas, China is facing domestic supply constraints that can only be solved through imports [21]. China's challenges with CO_2 and GPR make it an interesting case.

This research contributes to the energy and environment literature from the following aspects. First, as far as we know, this paper is the first to examine the effect of CO_2 on GPR. This paper demonstrates a bidirectional causality between China's GPR and CO_2 emissions. Our research fills this gap in the literature and lays the foundation for new theoretical analytical frameworks in geopolitical, environmental and energy economics. Second, existing studies ignore the possibility that the causal relationships between GPR and CO_2 may change. Our research adopts the rolling-window causality method in order to fully account for the time-varying characteristics of the causal relationship between them. In order to avoid improper structural changes, we have a fixed-size window on the scroll subsample of the causality test. Third, stakeholders in geopolitics and environmental economics can benefit from the relevant conclusions of this paper. Depending on its complex geopolitical risk characteristics and severe emission reduction process, Chinese policy makers can implement appropriate geopolitical strategies to manage sustainable development goals. We also offer advice that could benefit enterprises, social organizations and international organizations, such as increasing investment in new energy, developing green consciousness, regulating global decarbonization processes, etc.

This paper is divided into seven sections. Section 2 introduces the relevant literature review. Section 3 explains the methodology. Section 4 describes the corresponding data. The results obtained from empirical tests are given in Section 5. Section 6 is a discussion of the results. The last section gives the conclusion.

2. Literature Review

2.1. China's Geopolitical Risk Characteristics

First, China confronts complex GPR due to its geographic location. Zhao et al. [14] suggested that with 14 neighboring countries, China has more neighbors than any other country in the world and is prone to conflicts over territorial sovereignty and other issues. Husnain et al. [22] argued that the tension on the border between China and India has had distinct results and has affected social and economic stability. Second, China's major GPR comes from the energy sector. Song et al. [23] showed that China could be considered threatened in the field of energy supply and external dependence on energy. Due to its being the world's major energy demander, China would face severe supply challenges if sea lanes were to be disrupted [24]. Therefore, Zhou et al. [25] suggested that to meet the demand for energy security, China should diversify its imports by increasing cooperation with Central Asia, but this also intensifies competition among major powers and creates complex GPR related to energy competition. Yu et al. [26] revealed that under the influence of geopolitical risks, the South China Sea conflict potentially threatens China. Boyd and Ufimtseva [27] argued that it is necessary to completely comprehend energy security in the whole of geopolitical surroundings. Finally, China's international political status exacerbates its geopolitical risks. Sun et al. [28] showed that China has experienced obvious economic reconstruction and structural changes. Wang and Liu [17] revealed that since the end of the Cold War, relevant global regulations have evolved under the leadership of international organizations such as the United Nations, and GPR in China and the world have changed dramatically. Blackwell and Harris [29] suggested that the United States raising tariffs and revoking intellectual property access rights to China are to be regarded as "waging war by other means". Rogelja and Tsimonis [30] showed that China is seeking to balance the conflicting geopolitical environment because the United States and some countries increasingly doubt and resist China's rising political and economic power. Husnain et al. [22] argued that China is the second most powerful economy and has been the center of geopolitical tensions recently. Anser et al. [31] argued that, as part of the global climate change mitigation process, China has received sanctions related to CO_2 emissions.

2.2. Geopolitical Risk and Carbon Dioxide Emissions

In previous studies associating GPR and CO_2 emissions, scholars chose war, terrorism, political instability and other indicators as proxy variables of GPR. Bildirici and Gokmenoglu [32] studied eight countries, including Pakistan, and found that terrorism exacerbates CO_2 emissions. Bildirici [33] showed more terrorism causes more CO_2 emissions and energy consumption by studying the relationship between terrorism, environmental pollution and energy consumption in China, India and other countries. Jorgenson et al. [34] found that militarization results in high resource consumption and a large amount of pollution, which significantly influences CO_2 emissions. Gokmenoglu et al. [35] revealed the one-way causal nexus between military expenditures, which increases CO_2 emissions, and degradation of the environment. Ullah et al. [36] indicated that in the long and short term, militarization would affect the CO_2 emissions of Pakistan and India asymmetrically. In addition, some research has argued that there is a correlation between political stability and economic and environmental performance. Gani et al. [37] found that in developing economies such as China, political stability is significantly negatively correlated with per capita CO_2 emissions. Danish et al. [38] indicated that governance indicators of BRICS countries such as China, including political stability and government efficiency, have a striking adverse effect on CO_2 emissions.

Some studies have explored the impact of climate change on geopolitical risk proxy variables such as war, terrorism and political instability. Aribigbola et al. [39] showed that climate change will trigger terrorism and conflicts in many African countries. Kelley et al. [40] suggested that due to the temperature rise caused by CO_2, agriculture and water resources in the Middle East have been affected, which will further increase the risk of conflict in the region. In addition, Burke et al. [41] found that CO_2-induced warming is closely related to war. De Châtel [42] found that drought caused by rising temperatures has exacerbated political unrest in Syria, which has poor governance and unsustainable environmental policies. Sofuoğlu and Ay [43] revealed that climate change, such as CO_2, plays a double role in MENA countries because it triggers, accelerates and deepens current political instability.

However, previous studies have some limitations. Proxy variables such as war, terrorism and political instability used in the current literature cannot fully capture geopolitical events, and they show inconsistency over time [44]. Absent is a consistent indicator over time that measures real-time geopolitical tensions as perceived by the press, the public, global investors and policymakers. To overcome these limitations, Caldara and Lacoviello [9] developed the GPR index. It is constructed by calculating the occurrence rate of relevant words that resonate with geopolitical risks, extracted from 11 leading international newspapers (*The Boston Globe, Chicago Tribune, The Daily Telegraph, Financial Times, The Globe and Mail, The Guardian, Los Angeles Times, The New York Times, The Times, The Wall Street Journal and The Washington Post*). The advantage of the index is that it captures the risks associated with war, terrorism and political tensions [45].

There is some literature linking GPR and environmental quality. Anser et al. [31] used ecological footprint to represent environmental performance in emerging nations, including China, and found that GPR would significantly decrease it and retard environmental degradation. Further, scholars have focused on GPR and CO_2, with CO_2 being the variable chosen to represent environmental quality. Adams et al. [19] found GPR would increase CO_2 emissions in countries rich in natural resources such as China in the short term, but would inhibit it in the long term. Zhao et al. [10] recently found that over a long period of time, rising GPR will exacerbate CO_2 emissions in BRICS countries such as India and China. Anser et al. [46] also suggested that GPR in BRIC countries, including China, has escalated CO_2 emissions. In addition, Hashmi et al. [7] found that GPR would hinder CO_2 emissions at the global level for a short period, while in the long run it would do the opposite.

According to these discussions, it can be concluded that China has unique geopolitical risk characteristics. The existing research about the association between GPR and CO_2 emissions have contrasting outcomes that need to be reinvestigated for clear results. Particularly, there is no empirical investigation specifically for China. In addition, these studies mainly focus on linear correlations between variables, overlooking time variability.

3. Methodology

3.1. Bootstrap Full-Sample Causality Test

When the assumption that the required Granger causality statistical hypothesis stationarity is untenable, it indicates that the timeseries may not have a standard asymptotic distribution. In this case, estimation of a vector autoregressive model will be difficult [47]. The Monte Carlo simulation by Shukur and Mantolos [48] is used to improve the power and dimensional characteristics of the Wald test, but findings have indicated that there are still many deficiencies in small and medium-sized samples. Subsequently, Shukur and Mantalos [49] corrected for simulation ability and size by conducting a likelihood ratio (LR) test, showing good performance in small samples. In addition, a residual-based bootstrap (RB) process is used to solve problems with size and simulation ability in many studies [49–52]. Therefore, we adopt the modified LR test based on RB to explore the causality between Chinese GPR and CO_2 emissions. In Equation (1), the VAR (p) system with two variables is constructed.

$$X_t = \beta_0 + \beta_1 X_{t-1} + \ldots\ldots + \beta_p X_{t-p} + \varepsilon_t,\ t = 1,\ 2, \ldots\ldots, T \quad (1)$$

In this regard, Schwarz information criterion (SIC) is a useful method to determine lag length. In the bivariate VAR (p) system, we denote X as GPR and CO_2, that is $X_t = (GPR_t, CO_{2t})'$. Then, we can rewrite Equation (2) as follow:

$$\begin{bmatrix} GPR_t \\ CO_{2t} \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix} + \begin{bmatrix} \beta_{11}(L)\beta_{12}(L) \\ \beta_{21}(L)\beta_{22}(L) \end{bmatrix} \begin{bmatrix} GPR_t \\ CO_{2t} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad (2)$$

where $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$ is a white-noise process; $\beta_{ij}(L) = \sum_{k=1}^{p} \beta_{ij,k} L^k$; $i, j = 1, 2$ and L are the lag operators; then $L^k X_t = X_{t-k}$.

According to Equation (2), the null hypothesis that GPR is not the Granger reason of CO_2 can be examined, that is $\beta_{12,k} = 0$ for $k = 1, 2, \ldots\ \ldots, p$, and vice versa ($\beta_{21,k} = 0$ for $k = 1, 2, \ldots\ \ldots, p$).

3.2. Parameter Stability Test

To ensure validity of the empirical results. It is agreed that the parameters in the VAR system of the whole sample will not have time variability. Structural mutations may invalidate the full sample of test results, showing the instability of the causal relationship between sequences [53]. Parameter unsteadiness is a major challenge in empirical research [54]. Andrews [55] and Andrews and Ploberger [56] adopted the *sup-F, mean-F* and *Exp-F* tests to estimate stability of short-term period parameters. In addition, we also adopt L_C statistics test [57,58] to check whether the parameters are stable, so as to solve the substitution problem of single structural fracture in an unknown time. This test is calculated from LR statistical series. Further, the bootstrap subsample rolling-window test is used to estimate the critical values and p-values and then to study the specific impact between these two variables.

3.3. Subsample Rolling-Window Causality Test

Balcilar et al. [52] developed rolling-window bootstrap estimation to avoid test error, dividing the whole sample into multiple small parts. In rolling estimation, the causal relationship between variables can change over time. At the same time, instability can change between different subsamples due to structural changes. Pesaran and Timmermann [59] evaluated window size according to root mean square error, indicating that selection of the best window depends on the persistence and size of structural fracture. They propose that if the parameter is unstable, the minimum width of the window is 20. Specifically, we convert T full-scale observations with a fixed rolling-window width of l into a new sequence containing different observations. Finally, each separated part is displayed as l, $l + 1, \ldots \ldots, T$, and T-l + 1 different time series are obtained. Further, the modified LR test based on RB can estimate causality in subsamples rather than a single causality for the full sample. The results of GPR related to CO_2 are expressed as $N_b^{-1}\sum_{k=1}^{p} \hat{\beta}^*_{12,k}$, the average values of all bootstrap estimations. Similarly, the causality coefficient of CO_2 on GPR is displayed as $N_b^{-1}\sum_{k=1}^{p} \hat{\beta}^*_{21,k}$. Moreover, N_b indicates the frequency of repeated bootstraps, while $\hat{\beta}^*_{12,k}$ and $\hat{\beta}^*_{21,k}$ are parameters from Equation (2). The 90% confidence intervals are also computed, for which the lower and upper limits equal the 5th and 95th quantiles of each of the $\hat{\beta}^*_{12,k}$ and $\hat{\beta}^*_{21,k}$, respectively [52].

4. Data Source and Descriptive Analysis

We used monthly data from 2000:M01-2020:M12 to estimate the nexus between GPR and CO_2 emissions in China. The selected time period covers important GPR events such as the South China Sea issue (2000), the Diaoyu Islands incident (2012), Terminal High Altitude Area Defense (THAAD) into Korea (2016), Sino–US trade friction (2018) and China–India border conflict (2020). The variable of geopolitical risk is represented by GPR index (geopolitical risk data from policyuncertainty.com.), which was proposed by Caldara and Lacoviello [9]. It measures terrorism, trade disputes and political tensions affecting international transactions and national strategies, and the index has been broadly adopted in environmentalism [11,60,61]. The higher the GPR, the greater the risk associated with geopolitical risk events and vice versa [45]. Besides, we selected Chinese CO_2 emissions in tons per person as an indicator for measuring CO_2 emission level [38,62,63]. The data comes from the Organization for Economic Cooperation and Development (OECD). For empirical analysis, this study applies quadratic matching and summing to convert annual CO_2 data into monthly data. This method has been extensively available for economic analysis [64–66]. We treat the original data as a natural logarithm, which can avoid the potential heteroscedasticity between variable sequences [12,45,67].

Figure 2 shows trends in GPR and CO_2 emissions. The red line represents per capita CO_2 emissions and is calibrated by the right coordinate axis. The blue line represents the geopolitical risk index and is represented by the left coordinate axis. China's GPR fluctuate greatly, with several major node changes. In April 2001, an aircraft collision over the South China Sea between the United States and China strained relations. The outbreak of the SARS virus in February 2013 hit the Chinese and global economy and triggered GPR changes due to turbulence in the international situation. GPR was exacerbated in January 2013 when Chinese airpower flew close to what Japan called its air defense identification zone. In August 2019, the United States announced that it would raise tariffs on about $550 billion of Chinese goods, escalating trade friction into a trade war, which led China to file a case under the WTO dispute settlement mechanism. In June 2020, conflict between China and India at the border raised GPR. CO_2 emissions are generally on the rise, rising rapidly from 2.45 tons per person in 2000 to 7.45 tons per person in 2020. Table 1 describes the summary statistics for GPR and CO_2. The average values of GPR and CO_2 are 107.965 and 0.446, respectively. The positive skewness reflects that GPR is skewed to the right and CO_2 is skewed to the left. In addition, the values of kurtosis about GPR are greater than 3, indicating that it is a leptokurtic distribution. Besides, CO_2 is classified as a platykurtic distributions. Moreover, the Jarque–Bera test reveals that the variables have significantly nonnormal distributions.

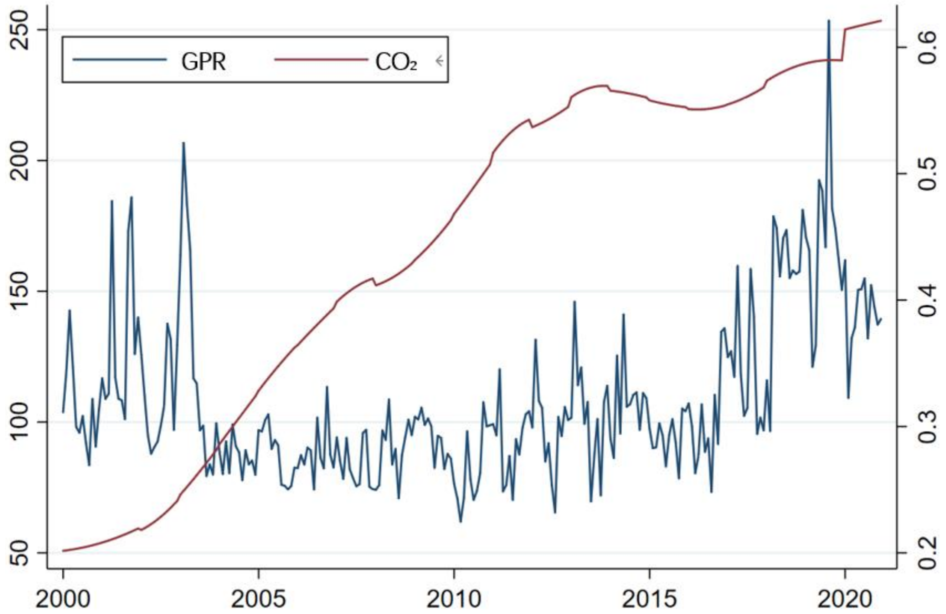

Figure 2. Trends of GPR and CO_2.

Table 1. Summary statistics for GPR and CO_2.

	Mean	Std. Dev	Skewness	Kurtosis	Jarque–Bera
GPR	107.965	30.741	1.398	5.035	125.514 ***
CO_2	0.446	0.135	−0.540	1.855	26.031 ***

Notes: *** denotes the 1% significance level.

5. Empirical Results

After taking logarithms of GPR and CO_2, this paper adopts the Augmented Dickey–Fuller [68] test, the Phillips–Perron [69] test and the Kwiatkowski–Phillips–Schmidt–Shin [70] test to investigate the stationarity of these two variables. It can be observed from Table 2 that the two timeseries are stable. Therefore, we can examine the causality between these two variables in the full samples by constructing a VAR system. In view of SIC, we set the optimal lag length to 5. The findings of the full sample causality are shown in Table 3, where its values indicate that there is no link between GPR and CO_2. It shows GPR cannot make a difference to CO_2 and that the converse is also true. The conclusion is inconsistent with prior research [14,46], which show GPR can positively affect CO_2.

Table 2. The results of unit root tests.

Variables	ADF	PP	KPSS
GPR	0.001 ***	0.000 ***	0.727 **
CO2	0.028 **	0.010 **	1.830 ***

Notes: *** and ** denote significance at the 1% and 5% levels, respectively.

Table 3. The full sample Granger causality test.

Tests	H_0: GPR Does Not Granger Cause CO_2		H_0: CO_2 Does Not Granger Cause GPR	
Bootstrap	Statistics	*p*-value	Statistics	*p*-value
LR test	3.400	0.620	3.088	0.686

All the above research was based on the default assumptions of no structural changes over the full time period considered and single causality [53]. In the case of structural mutation when using a full sample to estimate GPR and CO_2 emissions, if the parameters are time-varying, there must be an unstable impact on the relationship between GPR and CO_2.

As a result, the hypothesis tests of parameter invariance and single causality are no longer reliable throughout the sample period, and subsequent findings are unfounded [71]. Consequently, *Sup-F*, *Mean-F* and *Exp-F* tests [55,56] are applied to estimate short-term instability of GPR and CO_2 parameters in the above research model. At the same time, we perform statistical tests to verify whether parameter changes comply with the random walk. Table 4 shows the corresponding outcomes. Under the original assumption that the parameters remain unchanged, the *Sup-F* test results show that GPR, CO_2 and VAR system have experienced structural mutations at a level of 1%. In addition, the *Mean-F* and *Exp-F* tests revealed that the parameters change gradually over time. These results show that in GPR, CO_2 and VAR systems, the parameters can change gradually with time at the level of 1%. In summary, according to these results, it can be determined that due to the existence of parametric instability the full-sample causality test shows that there is no correlation between GPR and CO_2.

Table 4. The results of parameter stability test.

	GPR Equation		**CO_2 Equation**		**VAR System**	
	Statistics	***p*-Value**	**Statistics**	***p*-Value**	**Statistics**	***p*-Value**
Sup-F	44.550 ***	0.000	374.151 ***	0.000	138.045 ***	0.000
Mean-F	31.443 ***	0.000	43.487 ***	0.000	63.151 ***	0.000
Exp-F	18.678 ***	0.000	181.899 ***	0.000	64.251 ***	0.000
LC					9.180 ***	0.005

Notes: *** denotes significance at the 1% level.

In light of the structural mutation of parameters, testing the full sample only estimates the constant causality, which is unsuitable for this research. It also implies that there exists a time-varying impact between GPR and CO_2. Therefore, this paper adopts a rolling-window method to examine the causality between GPR and CO_2. Through the bootstrap *p*-values observed in different subsamples, possible changes of the two-way causal relationship between China's GPR and CO_2 are intuitively determined. The width of the rolling-window is supposed to be 36 to achieve higher accuracy of causality research. This will show if the original hypothesis that GPR is not a Granger reason of CO_2 is acceptable and vice versa. In addition, the mutual effect direction of the two can be judged by the figures. The rolling estimations of all subsamples are shown in Figures 3 and 4.

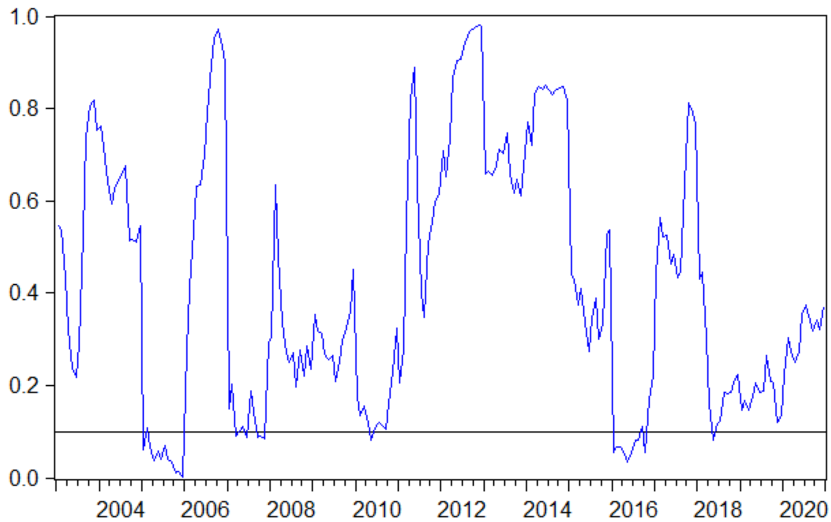

Figure 3. Bootstrap *p*-values of rolling test statistic testing the null hypothesis that GPR does not Granger cause CO_2.

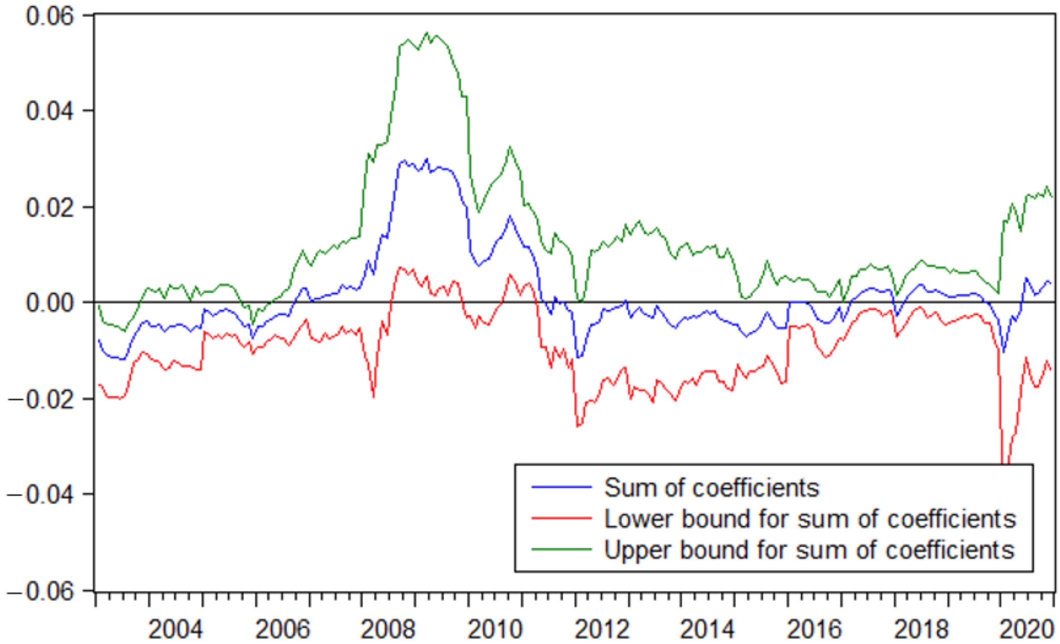

Figure 4. Bootstrap estimates of the sum of the rolling-window coefficients for the impact of GPR on CO_2. Notes: We can identify the direction of the impact of GPR on CO_2 through the average bound for sum of coefficients. If the average bound is greater than 0, GPR has a positive effect on CO_2 and vice versa. The upper and lower bounds for the sum of coefficients are based on the 5th and 95th quantile of $\hat{\beta}^{*}_{12,k}$, respectively.

Figures 3 and 4 report the results related to causal linkages of GPR on CO_2 and its influence. In the period of 2005:M01–2005:M12 and 2016:M01–2016:M10, GPR negatively affected CO_2. During the period of 2007:M08–2007:M11, positive causality between GPR and CO_2 is observed. The results show that GPR can affect CO_2 through effects on consumption, investment and mitigation.

Moving on to 2005:M01–2005:M12, China's energy import source was relatively single, and its dependence on foreign energy increased. The main sources of crude oil imports were the Middle East and Africa. During that time, oil supplies were tight because of political unrest in some major producing countries [72]. In August 2005, an explosion in Iran and unrest in Iraq impacted the crude oil market. If a major event occurs that affects the international energy market, countries with high energy dependence are confronted with higher threats of supply interruption [26]. There are geopolitical implications of energy security [73]. Chinese energy security was threatened, and its GPR increased. Its energy diplomacy strategy tends towards diversification, and GPR promote Chinese renewable energy investment. In addition, in response to energy-related GPR events, China has strengthened development of alternative energy sources. Different from developed countries in Europe and the United States, China's energy structure is highly dependent on coal [74]. More than half of electricity production is coal-fueled, and more than 70 percent of power plants are coal-fired. The ratio of electricity consumption and natural gas consumption to coal consumption is a good indicator of the energy consumption structure [75]. Policies promoting renewable energy as an alternative to coal have shifted energy production from coal to cleaner sources. This has improved the energy reserve system and strengthened the capacity of independent energy supply. From this, the impact of the investment effect is further confirmed. Environmental policies mainly focus on energy conservation and emission reduction, which slow the growth of carbon dioxide production, reflecting a negative impact. In the period of 2016:M01–2016:M10, the South China Sea standoff between the United States and China increased political tensions. The subsequent protectionist trade policy proposed by the Trump administration created great trade uncertainty for China. Trade friction against Chinese high-tech enterprises and the chip industry have always existed. Political tensions raised GPR, further hampering foreign trade. This posed new challenges for Chinese exports, economic growth and energy utilization. This is because rising political instability and tensions in other countries and regions are not conducive to sustainable economic growth [31]. From the perspective of mitigation effects, the reduction of energy consumption in economic production and related activities decreases CO_2 emissions. This indicate that the investment and mitigation effects seen in Figure 1 decrease CO_2.

In the period of 2007:M08–2007:M11, the South China Sea issue was a conflict about China and the Philippines, Malaysia and Vietnam. GPR related to it affected Chinese petroleum supply and posed a threat to the country. Intensified tensions in the region hindered or even stopped regional trade, disrupting China's economic development [76]. In 2007, China clashed with Vietnam several times, and in November, 2007, there were clashes along the Sino–Indian border. The increase in military activities reflected the rise of GPR in China. In consideration of the "consumption effect", pollution-intensive activities such as military activities emit more CO_2 and polluting gases by using more fossil fuel. At the same time, this period was the initial stage of the comprehensive development of Chinese renewable energy technology. For the sake of adapting to the needs of the development of the era, in 2007, National Renewable Energy Long-Term Planning was published, detailing the tasks and goals of China's renewable energy development. China lacked the core technologies and lagged behind advanced foreign countries. The backwardness of these technologies would eventually pose a threat to energy security and cause failure to meet commitments to reduce environmental pollution [77]. GPR between countries may affect China's green expenditure and advanced core communication technology. Figure 1 shows the positive impact of the consumption effect. The rise of geopolitical risk intensifies CO_2 emissions.

Figures 5 and 6 reveal the *p*-value and the influence direction of CO_2 on GPR. In 2015:M04–2017:M12 and 2019:M07-2020:M06, CO_2 positively influenced GPR. From 2018: M03–2018:M07, CO_2 had a negative effect on GPR. The results also confirm that CO_2 plays an active role in GPR through international behavior.

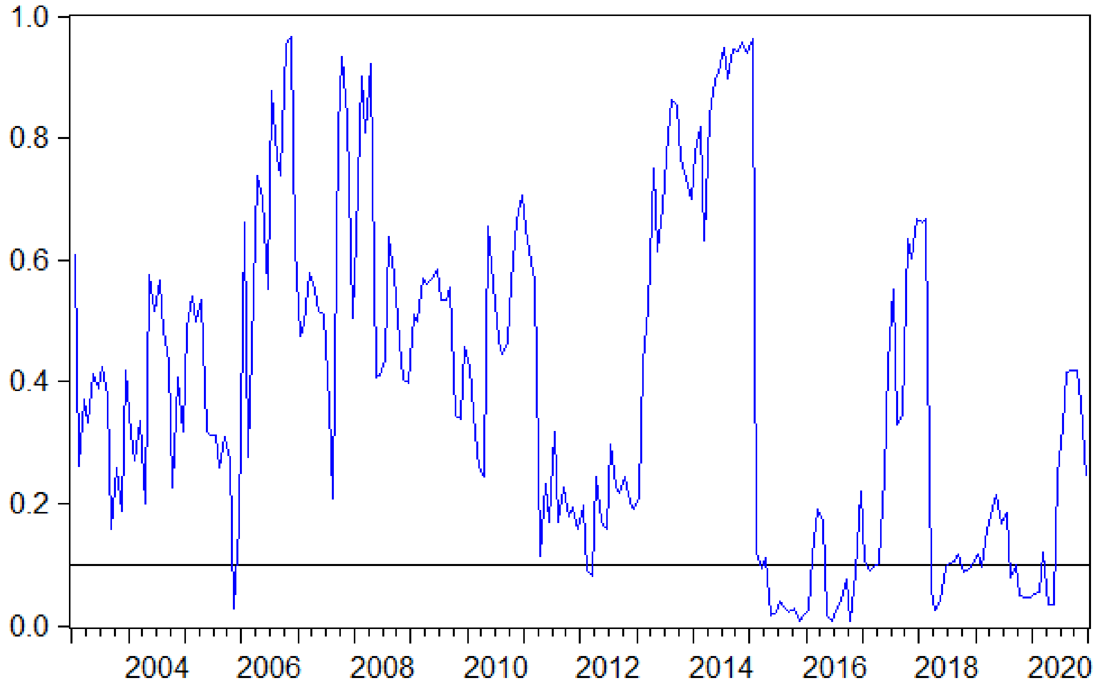

Figure 5. Bootstrap *p*-values of rolling test statistic testing the null hypothesis that CO_2 does not Granger cause GPR.

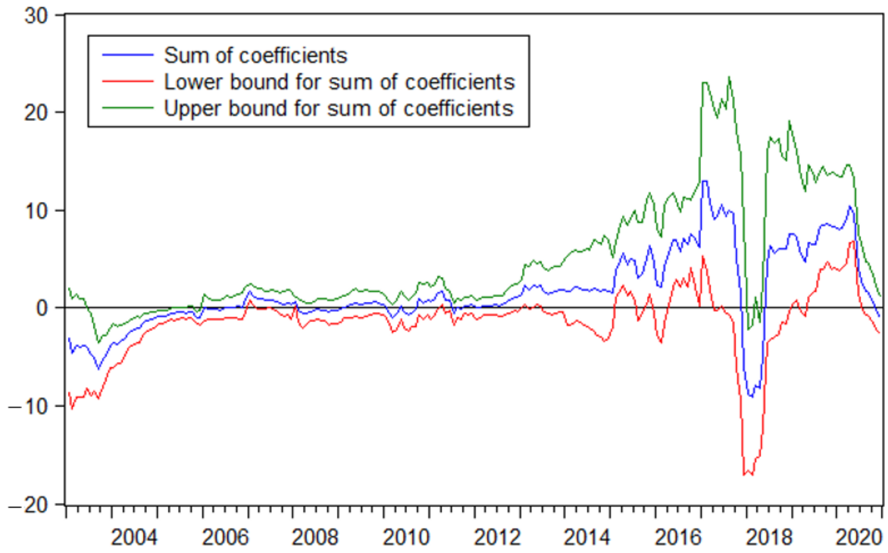

Figure 6. Bootstrap estimates of the sum of the rolling-window coefficients for the impact of CO_2 on GPR. Notes: We can identify the direction of the impact of CO_2 on GPR through the average bound for sum of coefficients. If the average bound is greater than 0, CO_2 has a positive effect on GPR and vice versa. The upper and lower bounds for sum of coefficients are based on the 5th and 95th quantile of $\hat{\beta}^*_{21,k}$, respectively.

In the period of 2015:M04–2017:M12, the Paris Agreement (adopted in December 2015) indicated that, although countries still have differences on how to reduce emissions and other aspects of tackling global warming, they agree on the need for strong international cooperation. Since 2015, China has taken an active part in global climate governance and assumed more and more responsibilities. In the same year, it surpassed the United States as the top clean-energy investor, with significant emissions reduction. China's CO_2 emissions showed a downward trend in 2015 and 2016. In 2017, its carbon intensity dropped by 46% compared with 2005, which reversed the initially rapid growth of CO_2 emissions [74]. In June 2015, China issued the EU–China Joint Declaration on Climate Change, and the China–EU Roadmap for Energy Cooperation followed in 2016, demonstrating that China and the EU have strengthened technical and economic cooperation regarding climate change and clean energy. In addition, in December 2017, China officially launched its carbon emission trading system, further promoting the construction of China's carbon market. It carries out international cooperation through both market and nonmarket means and further shifts its cooperation to green energy, a low-carbon economy, environmental governance and other fields. China's political leadership in the carbon environment has led to increased international cooperation and communication, contributing to a peaceful global environment and reducing GPR. In the time frame of 2019:M07–2020:M06, with the increasingly serious situation of global CO_2 emissions, the United States declared it would withdraw from the Paris Agreement (November 2019). It showed its preference for traditional fossil fuel energy and reduced restrictions on the development of fossil fuel energy, which slows decarbonization and emission reduction progress. The United States intensified pressure on China to reduce emissions, worsening Sino–US relations and escalating political tensions, which increases GPR for China. In December 2019, the results of the Madrid Climate Conference showed that developed countries failed to fully meet the calls of China and other developing countries for more financial, technological and capacity-building support. Developed countries use their advantages in climate change negotiations to squeeze other countries' Emission Permits through the global emission agreement [78]. As the task of decarbonization intensifies, climate justice is proposed. China used to be a major coal exporter, but due to the rapid growth of domestic coal consumption, it has become a net coal importer [21]. China has been seeking to reduce its reliance on coal as part of a pledge to cap its carbon emissions by 2030. China's National Bureau of Statistics released a report in 2019 showing that, while coal's fell 1.5%, coal consumption increased by 1%. Coal-fired power plant projects are still moving forward. According to the Global Carbon Project (GCP), most of the growth in global emissions in 2019 came from China, which added 260 million tons of CO_2. As China is the largest carbon emitter, unsatisfactory emission reduction is attracting attention from many countries. The growing trend in CO_2 emissions suggests that there will be more challenges from other countries regarding energy policies and sustainable development, which exacerbates geopolitical risks. These results show that international pushback against climate change as shown in Figure 1 have become the driving factor behind GPR.

Moving to 2018:M03–2018:M07, CO_2 emissions had a negative impact on GPR. China was vigorously promoting industrial restructuring, energy structure optimization, and low-carbon transformation [74]. Meanwhile, the C40 Cities Climate Leadership Group (C40) launched China's Cities Project in 2018, which aims to reduce urban CO_2 emissions and introduce clean energy to meet local energy needs. It develops green cooperation among cities and constantly explores concrete practices to cope with climate change. Carbon intensity dropped by 4 percent in 2018, a cumulative reduction of 45.8 percent from 2005. This is equivalent to China's emissions of 5.26 billion metric tons of CO_2, showing its effectiveness in encouraging green development. In 2018, at the United Nations Intergovernmental Panel on Climate Change (IPCC), China actively participated in global climate governance, significantly increasing its influence as a leading force in global climate governance. The international political cooperation that drives the response to global warming will significantly affect the geopolitical landscape. The EU has expanded its voice on climate change by promoting the implementation of the Kyoto Protocol and active emission reduction policies. The United States is trying to rebuild the global climate change negotiation framework and take the lead in the negotiation process [78]. Diplomacy has gradually shifted to climate diplomacy based on green and emission-reduction policies. In July 2008, China and the EU promulgated the Joint Declaration about Climate Change and Clean Energy. Subsequently, the two sides signed a memorandum of understanding on strengthening cooperation in carbon emission trading. China actively promoted international cooperation on adaptation to climate warming, which eased tensions over energy and the environment. In view of global warming, through mitigation measures to strengthen international cooperation, China's cooperation with all countries deepened, undermining its GPR. The influence of CO_2 on GPR mentioned in the hypothesis was again determined.

6. Discussion

In this section, we will briefly explain the results and their practical significance. In the full sample causality test, there is no relationship between GPR and CO_2 because the parameters in the VAR model are considered stable, but in fact there are structural changes. Therefore, this paper further uses different subsamples to obtain empirical results, indicating that China's geopolitical risk affects CO_2 emissions. The impact may be positive or negative. Geopolitical events such as energy security may result in energy independence or expansion of renewable energy, which obviously decreases CO_2 emissions. Considering the tension between regions, trade disputes and military activities impact economic production, thus changing CO_2 emissions. Therefore, the impacts of consumption, investment and mitigation proposed in our hypothesis have been proven.

Next, CO_2 will rewrite the rules of GPR. In the context of global climate governance, the impact of the competitive relationship between international cooperation and emission reduction endeavors, such as climate contracts, on geopolitical risks has been determined. This verifies our hypothesis that there is a two-way causal relationship between GPR and CO_2 emissions over time. It provides a more comprehensive perspective on the time-varying relationship between China's GPR and CO_2 emissions. This infers that controlling GPR factors is a new way for decision makers to achieve a pollution-free environment.

The literature [78–81] highlights the importance of geographic and political factors in China for energy and environmental outcomes. However, these studies provide no empirical evidence and are only based on qualitative discussions. Some studies [14,31,82,83] provide empirical evidence of GPR and environmental sectors in China and other countries. There is no detailed time-varying empirical discussion of the empirical results of these studies. In addition, the one-way influence results of this research is different from our two-way results.

7. Conclusions and Policy Implications

This paper analyzes the association between China's GPR and CO_2. The hypothesis presented in this paper is verified. Depending on rolling-window estimation, the results display a two-way time-varying causal relationship between GPR and CO_2 across different subsamples. GPR has a complex impact on CO_2 emissions through "consumption effect", "investment effect" and "mitigation effect". Oppositely, CO_2 through international cooperation also affects GPR. This study contributes to the available literature and is influential in formulating relevant environmental policies. First, we use the GPR index to clarify the time-varying relationship between China's GPR and CO_2 emissions. In this way, it expands the existing literature and supplements the content on how geopolitical risks change based on emissions reduction. It is worth noting that the rolling-window causality method makes the experimental results time-varying. Besides, we conducted the causality test of subsample rolling-window, which improved the accuracy and integrity. Last, studies of China have realistic significance. Based on the geopolitical security needs of global emissions reductions and correlation between GPR and CO_2, this paper provides critical policy recommendations for national policymakers and relevant departments and enterprises.

The policy implications are shown from the following aspects. First, government should consider geopolitical risks such as geographic location, energy security and trade disputes for their influence on the environment. Energy conservation, emissions reduction and the development of renewable energy can adequately address GPR and reduce the impact on CO_2 emissions. China's government ought to focus on investment in green technologies and improve the proportion of renewable energy in the energy structure. During periods of higher geopolitical risk, governments are likely to institute high carbon prices and strict environmental policies. In addition, the government can also increase investment in green development, such as policy subsidies related to sustainable development, which will enable participation in global economic activities at a deeper level. There should also be environmental cooperation agreements, green treaties and negotiations between countries to reduce GPR, and international environmental action is also necessary. Second, enterprises should focus on R&D, innovation and renewable energy investment, strengthening corporate awareness and action on climate warming management and the ability to actively fulfill carbon reduction obligations. It is also indispensable for enterprises to pay attention to the current international geopolitical situation to formulate their development strategies. They can also collaborate with companies in other countries on green technology projects. Third, the green behavior of the public is particularly important. Social organizations should carry out public awareness programs, and fostering environmental awareness can be an important tool to decrease CO_2 and GPR. Last, we can also pay attention to the supervision of international organizations issuing policies for rapid decarbonization of relevant national economies. Relevant international organizations can also be used as a useful tool to control GPR and solve conflicts between countries.

Future research can be extended to regional and national levels to further focus on the impact of GPR on the transition to renewable energy. The effect of GPR at high and low levels may be different. Therefore, this asymmetry will be discussed in the future. It is worth noting that this study has some limitations. First, monthly CO_2 data are not available. We converted annual data into monthly data, which may be inaccurate. In addition, GPR data may have a more direct impact at the micro level, such as the carbon emission level of enterprises, but there is a lack of relevant data.

Author Contributions: K.-H.W.: Writing—original draft, Methodology, Formal analysis. J.-M.K.: Conceptualization, Data curation. C.-F.J.: Supervision, Project administration. C.-W.S.: Software, Formal analysis. All authors have read and agreed to the published version of the manuscript.

Funding: This research has been supported by the Social Science Foundation of Shandong, China (Grant Number: 21DJJJ).

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Abidoye, B.O.; Odusola, A.F. Climate Change and Economic Growth in Africa: An Econometric Analysis. *J. Afr. Econ.* **2015**, *24*, 277–301. [CrossRef]
2. Tol, R.S.J. The Economic Impacts of Climate Change. *Rev. Environ. Econ. Policy* **2018**, *12*, 4–25. [CrossRef]
3. Ignjacevic, P.; Estrada, F.; Botzen, W.J.W. Time of emergence of economic impacts of climate change. *Environ. Res. Lett.* **2021**, *16*, 074039. [CrossRef]
4. Seetanah, B.; Sannassee, R.V.; Fauzel, S.; Soobaruth, Y.; Giudici, G.; Nguyen, A.P.H. Impact of Economic and Financial Development on Environmental Degradation: Evidence from Small Island Developing States (SIDS). *Emerg. Mark. Financ. Trade* **2018**, *55*, 308–322. [CrossRef]
5. Kahia, M.; Ben Jebli, M.; Belloumi, M. Analysis of the impact of renewable energy consumption and economic growth on carbon dioxide emissions in 12 MENA countries. *Clean Technol. Environ. Policy* **2019**, *21*, 871–885. [CrossRef]
6. Coskuner, C.; Paskeh, M.K.; Olasehinde-Williams, G.; Akadiri, S.S. Economic and social determinants of carbon emissions: Evidence from organization of petroleum exporting countries. *J. Public Aff.* **2020**, *20*, e2092. [CrossRef]
7. Hashmi, S.M.; Bhowmik, R.; Inglesi-Lotz, R.; Syed, Q.R. Investigating the Environmental Kuznets Curve hypothesis amidst geopolitical risk: Global evidence using bootstrap ARDL approach. *Environ. Sci. Pollut. Res.* **2021**, *29*, 24049–24062. [CrossRef]
8. Apergis, N.; Garzón, A.J. Greenhouse gas emissions convergence in Spain: Evidence from the club clustering approach. *Environ. Sci. Pollut. Res.* **2020**, *3*, 38602–38606. [CrossRef]
9. Caldara, D.; Iacoviello, M. *Measuring Geopolitical Risk*; International Finance Discussion Papers; Number 1222; FRB: Washington, DC, USA, 2018; pp. 1–66.
10. Akadiri, S.S.; Eluwole, K.K.; Akadiri, A.C.; Avci, T. Does causality between geopolitical risk, tourism and economic growth matter? Evidence from Turkey. *J. Hosp. Tour. Manag.* **2020**, *43*, 273–277. [CrossRef]
11. Rasoulinezhad, E.; Taghizadeh-Hesary, F.; Sung, J.; Panthamit, N. Geopolitical Risk and Energy Transition in Russia: Evidence from ARDL Bounds Testing Method. *Sustainability* **2020**, *12*, 2689. [CrossRef]
12. Su, C.W.; Khan, K.; Tao, R.; Nicoleta-Claudia, M. Does geopolitical risk strengthen or depress oil prices and financial liquidity? Evidence from Saudi Arabia. *Energy* **2019**, *187*, 116003. [CrossRef]
13. Wang, X.; Wu, Y.; Xu, W. Geopolitical risk and investment. *SSRN* **2019**, 3305739. [CrossRef]
14. Zhao, W.; Zhong, R.; Sohail, S.; Majeed, M.T.; Ullah, S. Geopolitical risks, energy consumption, and CO_2 emissions in BRICS: An asymmetric analysis. *Environ. Sci. Pollut. Res.* **2021**, *28*, 39668–39679. [CrossRef] [PubMed]
15. Al-Nuaimi, S.; Banawi, A.A.A.; Al-Ghamdi, S.G. Environmental and economic life cycle analysis of primary construction materials sourcing under geopolitical uncertainties: A case study of Qatar. *Sustainability* **2019**, *11*, 6000. [CrossRef]
16. Ladislaw, S.O.; Leed, M.; Walton, M.A. *New Energy, New Geopolitics: Balancing Stability and Leverage*; Center for Strategic and International Studies: Washington, DC, USA, 2014.
17. Wang, W.; Liu, Y. Geopolitics of global climate change and energy security. *Chin. J. Popul. Resour. Environ.* **2015**, *13*, 119–126. [CrossRef]
18. Sweidan, O.D. The geopolitical risk effect on the us renewable energy deployment. *J. Clean. Prod.* **2021**, *293*, 126189. [CrossRef]
19. Adams, S.; Adedoyin, F.; Olaniran, E.; Bekun, F.V. Energy consumption, economic policy uncertainty and carbon emissions; causality evidence from resource rich economies. *Econ. Anal. Policy* **2020**, *68*, 179–190. [CrossRef]
20. Kong, Y.; Feng, C.; Yang, J. How does China manage its energy market? A perspective of policy evolution. *Energy Policy* **2020**, *147*, 111898. [CrossRef]
21. Yu, L.L.; Li, Z. Research on China's energy external dependence and energy strategy. *E3S Web Conf.* **2021**, *245*, 01047.
22. Husnain, M.I.U.; Syed, Q.R.; Bashir, A.; Khan, M.A. Do geopolitical risk and energy consumption contribute to environmental degradation? Evidence from E7 countries. *Environ. Sci. Pollut. Res.* **2021**, *29*, 41640–41652. [CrossRef]
23. Song, Y.; Zhang, M.; Sun, R. Using a new aggregated indicator to evaluate China's energy security. *Energy Policy* **2019**, *132*, 167–174. [CrossRef]
24. Li, J.; Wang, L.; Lin, X.; Qu, S. Analysis of China's energy security evaluation system: Based on the energy security data from 30 provinces from 2010 to 2016. *Energy* **2020**, *198*, 117346.1–117346.11. [CrossRef]
25. Zhou, Q.; He, Z.; Yang, Y. Energy geopolitics in Central Asia: China's involvement and responses. *J. Geogr. Sci.* **2020**, *30*, 1871–1895. [CrossRef]
26. Yu, Z.; Xiao, Y.; Li, J.P. How does geopolitical uncertainty affect Chinese overseas investment in the energy sector? Evidence from the South China Sea Dispute. *Energy Econ.* **2021**, *100*, 105361. [CrossRef]

27. Boyd, R.; Ufimtseva, A. Facilitating peaceful rise: The increasing role of geopolitics and domestic legitimacy in China's energy policy. *Energy Policy* **2021**, *158*, 112532. [CrossRef]
28. Sun, J.L.; Tao, R.; Wang, L.; Jin, L.M. Does Social Medical Insurance Achieve a Poverty Reduction Effect in China? *Front. Public Health* **2021**, *9*, 800852. [CrossRef]
29. Blackwell, R.D.; Harris, J.M. *War by Other Means: Geoeconomics and Statecraft*; Harvard University Press: Cambrige, MA, USA, 2016.
30. Rogelja, I.; Tsimonis, K. Narrating the China Threat: Securitising Chinese Economic Presence in Europe. *Chin. J. Int. Politics* **2020**, *13*, 103–133. [CrossRef]
31. Anser, M.K.; Syed, Q.R.; Lean, H.H.; Alola, A.A.; Ahmad, M. Do Economic Policy Uncertainty and Geopolitical Risk Lead to Environmental Degradation? Evidence from Emerging Economies. *Sustainability* **2021**, *13*, 5866. [CrossRef]
32. Bildirici, M.; Gokmenoglu, S.M. The impact of terrorism and FDI on environmental pollution: Evidence from Afghanistan, Iraq, Nigeria, Pakistan, Philippines, Syria, Somalia, Thailand and Yemen. *Environ. Impact Assess. Rev.* **2020**, *81*, 106340. [CrossRef]
33. Bildirici, M.E. Terrorism, environmental pollution, foreign direct investment (FDI), energy consumption, and economic growth: Evidences from China, India, Israel, and Turkey. *Energy Environ.* **2020**, *32*, 75–95. [CrossRef]
34. Jorgenson, A.K.; Clark, B.; Kentor, J. Militarization and the environment: A panel study of carbon dioxide emissions and the ecological footprints of nations, 1970–2000. *Glob. Environ. Politics* **2010**, *10*, 7–29. [CrossRef]
35. Gokmenoglu, K.K.; Taspinar, N.; Rahman, M.M. Military expenditure, financial development and environmental degradation in Turkey: A comparison of CO_2 emissions and ecological footprint. *Int. J. Financ. Econ.* **2020**, *26*, 986–997. [CrossRef]
36. Ullah, S.; Andlib, Z.; Majeed, M.T.; Sohail, S.; Chishti, M.Z. Asymmetric effects of militarization on economic growth and environmental degradation: Fresh evidence from Pakistan and India. *Environ. Sci. Pollut. Res.* **2021**, *28*, 9484–9497. [CrossRef]
37. Gani, A. The relationship between good governance and carbon dioxide emissions: Evidence from developing economies. *J. Econ. Dev.* **2012**, *37*, 77–93. [CrossRef]
38. Danish; Baloch, M.A.; Wang, B. Analyzing the role of governance in CO_2 emissions mitigation: The BRICS experience. *Struct. Chang. Econ. Dyn.* **2019**, *52*, 119–125.
39. Aribigbola, A.; Folami, O.M.; Folami, A.O. Climate change and insecurity are like a chain reaction. *Peace Rev.* **2013**, *25*, 518–525. [CrossRef]
40. Kelley, C.P.; Mohtadi, S.; Cane, M.A.; Seager, R.; Kushnir, Y. Climate change in the Fertile Crescent and implications of the recent Syrian drought. *Proc. Natl. Acad. Sci. USA* **2015**, *112*, 3241–3246. [CrossRef]
41. Burke, M.B.; Miguel, E.; Satyanath, S.; Dykema, J.A.; Lobell, D.B. Warming increases the risk of civil war in Africa. *Proc. Natl. Acad. Sci. USA* **2009**, *106*, 20670–20674. [CrossRef]
42. De Châtel, F. The role of drought and climate change in the Syrian uprising: Untangling the triggers of the revolution. *Middle East Stud.* **2014**, *50*, 521–535. [CrossRef]
43. Sofuoğlu, E.; Ay, A. The relationship between climate change and political instability: The case of MENA countries (1985:01–2016:12). *Environ. Sci. Pollut. Res.* **2020**, *27*, 14033–14043. [CrossRef]
44. Bouoiyour, J.; Selmi, R.; Hammoudeh, S.; Wohar, M.E. What are the categories of geopolitical risks that could drive oil prices higher? Acts or threats? *Energy Econ.* **2019**, *84*, 104523. [CrossRef]
45. Su, C.-W.; Qin, M.; Tao, R.; Shao, X.-F.; Albu, L.L.; Umar, M. Can Bitcoin hedge the risks of geopolitical events? *Technol. Forecast. Soc. Chang.* **2020**, *159*, 120182. [CrossRef]
46. Anser, M.K.; Syed, Q.R.; Apergis, N. Does geopolitical risk escalate CO_2 emissions? Evidence from the BRICS countries. *Environ. Sci. Pollut. Res.* **2021**, *28*, 48011–48021. [CrossRef] [PubMed]
47. Sims, C.A.; Stock, J.H.; Watson, M.W. Inference in linear time series models with some unit roots. *Econometrica* **1990**, *58*, 113–144. [CrossRef]
48. Shukur, G.; Mantalos, P. *Size and Power of the RESET Test as Applied to Systems of Equations: A Bootstrap Approach*; Department of Statistics, University of Lund Working Paper: Lund, Sweden, 1997.
49. Shukur, G.; Mantalos, P. A Simple Investigation of the Granger-causality Test in Integrated-Cointegrated VAR Systems. *J. Appl. Stat.* **2000**, *27*, 1021–1031. [CrossRef]
50. Mantalos, P.; Shukur, G. Size and Power of the Error Correction Model Cointegration Test: A Bootstrap Approach. *Oxf. Bull. Econ. Stat.* **1998**, *60*, 249–255. [CrossRef]
51. Mantalos, P. A Graphical Investigation of the Size and Power of the Granger-causality Tests in Integrated-Cointegrated VAR Systems. *Stud. Nonlinear Dyn. Econom.* **2000**, *4*, 17–33. [CrossRef]
52. Balcilar, M.; Ozdemir, Z.A.; Arslanturk, Y. Economic growth and energy consumption causal nexus viewed through a bootstrap rolling window. *Energy Econ.* **2010**, *32*, 1398–1410. [CrossRef]
53. Balcilar, M.; Ozdemir, Z.A. The export-output growth nexus in Japan: A bootstrap rolling window approach. *Empir. Econ.* **2013**, *44*, 639–660. [CrossRef]
54. Granger, C.W.J. Can we improve the perceived quality of economic forecasts? *J. Appl. Econom.* **1996**, *11*, 455–473. [CrossRef]
55. Andrews, D.W.K. Tests for parameter instability and structural change with unknown change point. *Econometrica* **1993**, *61*, 821–856. [CrossRef]
56. Andrews, D.W.K.; Ploberger, W. Optimal tests when a nuisance parameter is present only under the alternative. *Econometrica* **1994**, *62*, 1383–1414. [CrossRef]

57. Nyblom, J. Testing for the constancy of parameters over time. *J. Am. Stat. Assoc.* **1989**, *84*, 223–230. [CrossRef]
58. Hansen, B.E. Tests for parameter instability in regressions with I (1) processes. *J. Bus. Econ. Stat.* **1992**, *20*, 45–59. [CrossRef]
59. Pesaran, M.H.; Timmermann, A. Small Sample Properties of Forecasts from Autoregressive Models under Structural Breaks. *J. Econom.* **2005**, *129*, 183–217. [CrossRef]
60. Qin, Y.; Hong, K.R.; Chen, J.Y.; Zhang, Z.T. Asymmetric effects of geopolitical risks on energy returns and volatility under different market conditions. *Energy Econ.* **2020**, *90*, 104851. [CrossRef]
61. Yang, K.; Wei, Y.; Li, S.W.; He, J.M. Geopolitical risk and renewable energy stock markets: An insight from multiscale dynamic risk spillover. *J. Clean. Prod.* **2020**, *279*, 123429. [CrossRef]
62. Saidi, K.; Hammami, S. The impact of CO_2 emissions and economic growth on energy consumption in 58 countries. *Energy Rep.* **2015**, *1*, 62–70. [CrossRef]
63. Syed, Q.R.; Bouri, E. Impact of economic policy uncertainty on CO_2 emissions in the US: Evidence from bootstrap ARDL approach. *J. Public Aff.* 2021; in press.
64. Shahbaz, M.; Chaudhary, A.R.; Ozturk, I. Does urbanization cause increasing energy demand in Pakistan? Empirical evidence from STIRPAT model. *Energy* **2017**, *122*, 83–93. [CrossRef]
65. Ozcan, B.; Tzeremes, P.; Dogan, E. Re-estimating the interconnectedness between the demand of energy consumption, income, and sustainability indices. *Environ. Sci. Pollut. Res.* **2019**, *26*, 26500–26516. [CrossRef] [PubMed]
66. Sharif, A.; Mishra, S.; Sinha, A.; Jiao, Z.; Shahbaz, M.; Afshan, S. The renewable energy consumption-environmental degradation nexus in top-10 polluted countries: Fresh insights from quantile-on-quantile regression approach. *Renew. Energy* **2020**, *150*, 670–690. [CrossRef]
67. Bildirici, M.E. The causal link among militarization, economic growth, CO_2 emission, and energy consumption. *Environ. Sci. Pollut. Res.* **2016**, *24*, 4625–4636. [CrossRef] [PubMed]
68. Dickey, D.A.; Fuller, W.A. Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica* **1981**, *49*, 1057–1072. [CrossRef]
69. Phillips, P.C.B.; Perron, P. Testing for a Unit Root in Time Series Regression. *Biometrika* **1988**, *75*, 335–346. [CrossRef]
70. Kwiatkowski, D.; Phillips, P.C.B.; Schmidt, P.; Shin, Y. Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *J. Econom.* **1992**, *54*, 159–178. [CrossRef]
71. Zeileis, A.; Leisch, F.; Hornik, K.; Kleiber, C. Monitoring Structural Change in Dynamic Econometric Models. *J. Appl. Econom.* **2005**, *20*, 99–121. [CrossRef]
72. Khan, K.; Su, C.W.; Umar, M.; Yue, X.G. Do crude oil price bubbles occur? *Resour. Policy* **2020**, *71*, 101936. [CrossRef]
73. Overland, I. The geopolitics of renewable energy: Debunking four emerging myths. *Energy Res. Soc. Sci.* **2019**, *49*, 36–40. [CrossRef]
74. Wang, Y.; Guo, C.H.; Chen, X.J.; Jia, L.Q.; Guo, X.N.; Chen, R.S.; Zhang, M.S.; Chen, Z.Y.; Wang, H.D. Carbon peak and carbon neutrality in China: Goals, implementation path and prospects. *China Geol.* **2022**, *4*, 720–746. [CrossRef]
75. Zeng, S.; Su, B.; Zhang, M.L.; Gao, Y.; Liu, J.; Luo, S.; Tao, Q.M. Analysis and forecast of China's energy consumption structure. *Energy Policy* **2021**, *159*, 112630. [CrossRef]
76. Zhong, H.; White, M. South China Sea: Its importance for shipping, trade, energy and fisheries. *Asia-Pac. J. Ocean Law Policy* **2017**, *2*, 9–24. [CrossRef]
77. Bonnet, C.; Carcanague, S.; Hache, E.; Seck, G.S.; Simoën, M. *The Nexus between Climate Negotiations and Low-Carbon Innovation: A Geopolitics of Renewable Energy Patents*; EconomiX-UMR7235; Universit'e Paris Nanterre: Nanterre, France, 2018.
78. Wang, L.; Gu, M.; Li, H. Influence path and effect of climate change on geopolitical pattern. *J. Geogr. Sci.* **2012**, *22*, 1117–1130. [CrossRef]
79. Sun, G.; Yuan, C.; Hafeez, M.; Raza, S.; Jie, L.; Liu, X. Does regional energy consumption disparities assist to control environmental degradation in OBOR: An entropy approach. *Environ. Sci. Pollut. Res.* **2019**, *27*, 7105–7119. [CrossRef] [PubMed]
80. Hu, J.Y.; Wang, K.H.; Su, C.W.; Umar, M. Oil price, green innovation and institutional pressure: A China's perspective. *Resour. Policy* **2022**, *78*, 102788. [CrossRef]
81. Wang, K.H.; Liu, L.; Li, X.; Lobont, O.R. Do oil price shocks drive unemployment? Evidence from Russia and Canada. *Energy* **2022**, *253*, 124107. [CrossRef]
82. Wang, K.H.; Su, C.W.; Xiao, Y.D.; Liu, L. Is the oil price a barometer of China's automobile market? From a wavelet-based quantile-on-quantile regression perspective. *Energy* **2022**, *240*, 122501. [CrossRef]
83. Wang, K.H.; Zhao, Y.X.; Jiang, C.F.; Li, Z.Z. Does green finance inspire sustainable development? Evidence from a global perspective. *Econ. Anal. Policy* **2022**, *75*, 412–426. [CrossRef]