RESEARCH ARTICLE

Geopolitics and the Planet: Does Geopolitical Risk Drive Carbon Emissions?

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Abstract

This study investigates the relationship between geopolitical risk (GPR) and carbon emissions (CE) in the United States using monthly data from January 1985 to November 2025. Employing Vector Autoregression (VAR) and Nonlinear Autoregressive Distributed Lag (NARDL) models, we examine both linear and asymmetric effects of geopolitical risk on carbon emissions. Our empirical results reveal that geopolitical risk and carbon emissions exhibit a weak negative correlation over the full sample period, with the correlation coefficient being -0.11. However, this relationship varies significantly across different time periods, ranging from -0.29 during 1985-2000 to -0.17 during 2001-2008. The VAR model analysis indicates that while GPR shocks have limited immediate impact on carbon emissions changes, the dynamic responses show complex patterns over time. Granger causality tests suggest no significant causal relationship between GPR and carbon emissions in either direction. The NARDL model results demonstrate that both positive and negative GPR shocks have insignificant effects on carbon emissions, suggesting that the impact of geopolitical risk on carbon emissions is symmetric but statistically weak. These findings contribute to the ongoing debate on the environmental consequences of geopolitical tensions and provide important policy implications for climate governance in an era of heightened geopolitical uncertainty.

Keywords: Geopolitical risk; Carbon emissions; VAR model; NARDL model; Climate governance; United States

JEL Classification: Q54; Q58; F51; C32

1. INTRODUCTION

In recent years, the frequent occurrence of extreme weather events has posed severe challenges to environmental governance and socio-economic development, making carbon emissions a focal point of global attention. Over the past few years, phenomena such as terrorism, war, conflict, militarization, and political pressures both domestically and internationally have intensified worldwide. To some extent, such risks may lead to a contraction in economic scale and energy consumption, promoting the transformation and upgrading of energy and industrial structures, thereby reducing carbon emissions. However, geopolitical risks can also lead to the deterioration of international relations, hindering global cooperation on carbon emissions and climate change response, thus increasing carbon emission risks. For example, after the United States and Israel launched a military strike on Iran on February 28, 2026, Iran immediately announced the closure of the Strait of Hormuz, causing nearly one-third of global seaborne oil transport to be interrupted and severely disrupting energy and trade supply chains in Eurasia. This raises a key question: in the context of rising geopolitical risks, will countries turn to renewable energy or coal? Will carbon emissions ultimately increase or decrease? Currently, there is no consensus in academia on the relationship between geopolitical risks and carbon emissions. Therefore, this paper's objective is to explore the intrinsic effect of geopolitical risk on carbon emissions.

Climate change is one of the most urgent issues today. By 2100, the global average temperature is expected to rise by 3-5℃, which could have devastating consequences for the Earth. Since the adoption of the Paris Climate Agreement in 2015, which explicitly set the core goal of achieving net-zero emissions in the second half of this century, the concept of carbon neutrality has been deeply integrated into the global development agenda and has become a common pursuit of countries around the world. Currently, 127 countries have explicitly proposed or plan to propose carbon neutrality visions, covering 90% of the global GDP, 85% of the population, and 88% of carbon emissions. At the same time, global geopolitical risks are showing a trend of normalized spread, with terrorism, war conflicts, and militarization intensifying, and their disturbances to energy supply, industrial development, and international cooperation gradually permeating the entire process of carbon emission control, becoming a key variable affecting the global decarbonization process. Specifically, the impact of geopolitical risk on carbon emissions shows significant bidirectionality.

On the one hand, geopolitical risks can suppress the growth of carbon emissions. Firstly, geopolitical conflicts trigger energy supply shortages and price surges, forcing businesses and residents to reduce energy consumption, especially in high-energy-consuming industries, thereby leading to a decline in carbon emissions. For example, at the early stage of the Russia-Ukraine conflict, European energy prices soared, industrial enterprises reduced production scales, and residents reduced energy consumption related to heating and travel, resulting in a short-term slight decrease in carbon emissions. Secondly, to respond to common geopolitical risks, countries with bound geopolitical interests may strengthen climate cooperation and jointly advance emission reduction actions, thus suppressing the growth of carbon emissions. For example, under the energy crisis, some European countries accelerated the interconnection of new energy within the region, temporarily improving emission reduction efficiency. Thirdly, heightened geopolitical risks can inhibit cross-border investment, obstruct international trade, and damage market confidence, leading to a contraction in global economic activity, a decline in output in high-energy-consuming sectors such as industrial production, transport logistics, and construction, thereby reducing carbon emissions.

On the other hand, geopolitical risks can promote the growth of carbon emissions. Firstly, geopolitical confrontation will exacerbate the disruption of national climate cooperation, hinder the implementation of global climate agreements and the interconnection of carbon markets. This will reduce countries' motivation to cut emissions, thereby increasing the risk of carbon emissions in the long term. Secondly, geopolitical conflicts trigger a restructuring of global supply chains, causing energy-intensive industries to return to countries or regions with low energy costs and lenient environmental standards. As a result, carbon emissions in these areas will increase significantly, leading to a decrease in overall global emission reduction efficiency. Thirdly, long-term geopolitical conflicts have triggered a large number of military confrontations, weapon production, military exercises, and other activities. This consumes a large amount of fossil energy, and the construction of military facilities as well as reconstruction projects after war destruction also generate huge carbon emissions, which long-term drive carbon emissions upward.

Given these competing theoretical predictions, empirical investigation is essential to determine the net effect of geopolitical risk on carbon emissions. This study contributes to the literature in several ways. First, we employ both VAR and NARDL models to examine both linear and nonlinear relationships between GPR and CE, providing a more comprehensive analysis than previous studies that have typically focused on linear relationships. Second, we use a long time series of monthly data spanning over 40 years, which allows us to capture the dynamic evolution of this relationship across different geopolitical and economic contexts. Third, we focus on the United States, which is the world's second-largest emitter of carbon dioxide and has unique geopolitical and energy security characteristics that make it an important case study.

2. LITERATURE REVIEW

There is growing literature focusing on the impact of geopolitical risk on carbon emissions but failing to reach a consensus. Some studies maintain the negative effects of geopolitical risk on carbon emissions. Banerjee et al. (2025) state that the increase in geopolitical risk will prompt companies to actively reduce carbon emissions, and the reduction of carbon emissions is a strategic choice for companies to cope with political scrutiny. Li et al. (2025) suggest that the increase in geopolitical risk can reduce energy demand in low-income countries and decrease carbon emissions. In addition, industrial structure upgrading will strengthen this negative effect, further lowering the carbon reduction coefficient of geopolitical risks. Wang et al. (2022) note that the rise in geopolitical risk will intensify tensions between regions, trade disputes, and military activities, thereby affecting economic production and curbing carbon emissions. However, this view can only sometimes be held. Zhao et al. (2025) hold that high geopolitical risk exerts a substantial and significant negative impact on national decarbonization willingness. This suppressive effect can threaten the International Maritime Organization's timetable for achieving zero-carbon shipping. Irfan et al. (2024) point out that uncertainty caused by geopolitical conflicts reduces investment efficiency, disturbs energy market stability, and raises the cost of green technology adoption. As a result, industrial production tends to maintain high fossil fuel consumption, leading to higher carbon emissions. Shanyazov et al. (2026) that further show that in the long run, geopolitical risk exerts positive and statistically significant effects on per capita carbon emissions in G7 economies. Specifically, a 1% increase in the geopolitical risk index leads to a 0.042% rise in per capita carbon emissions. Uddin et al. (2023) indicate that geopolitical tensions restrict cross-border cooperation on environmental protection, hinder the transfer of clean technologies, and raise energy prices. These forces push economies to rely on domestic high-carbon energy sources, which further drives emissions growth.

The transition mechanism from geopolitical risk to carbon emissions has garnered increasing interest from scholars over the years, primarily reflected in four aspects. Firstly, the geopolitical risk could influence carbon emissions through the energy consumption channel. Wang et al. (2022) find that 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 will escalate carbon emissions. Secondly, the geopolitical risk could influence carbon emissions through the global climate governance channel. Secondly, Su et al. (2021) suggest that the instability of governance systems caused by geopolitical risks may lead to a slowdown in international cooperation, thereby limiting countries' collective ability to address climate change and achieve low-carbon goals. Thirdly, Kızılkaya et al. (2024) indicate that rising geopolitical risk reduces carbon emissions by suppressing production in high-pollution industries and economic growth, which means that economic contraction is an important transmission mechanism. Fourth, the geopolitical risk could influence carbon emissions through the industrial structure channel. Li et al. (2024) demonstrate that with the continuous upgrading of the industrial structure, the impact of geopolitical risks on carbon emissions has changed from positive to negative. This indicates that the upgrading of industrial structure plays an important role in mitigating the negative impact of geopolitical risks on carbon emissions.

In short, the existing literature presents mixed findings regarding the relationship between geopolitical risk and carbon emissions. While some studies find a negative relationship, others report positive or insignificant effects. These contradictory results may be attributed to differences in sample periods, geographical coverage, and methodological approaches. Most existing studies focus on linear relationships, with limited attention to potential nonlinearities and asymmetries. This study aims to contribute to this debate by providing new empirical evidence from the United States using advanced econometric techniques that can capture both linear and nonlinear dynamics.

3. METHODOLOGY

3.1 Data Description

This study employs monthly data covering the period from January 1985 to November 2025, comprising 491 observations. This long time span allows us to capture the relationship between geopolitical risk and carbon emissions across multiple business cycles, geopolitical events, and policy regimes. The data frequency (monthly) is appropriate for analyzing the dynamic interactions between these variables, as both geopolitical events and emission changes can manifest at relatively high frequencies.

The geopolitical risk index (GPR) is obtained from the Economic Policy Uncertainty Database maintained by Caldara and Iacoviello (2022), which measures adverse geopolitical events and associated risks through automated text-search analysis of newspaper articles. The GPR index is constructed by counting the number of articles related to geopolitical risk in leading international newspapers, normalized by the total number of articles. The index captures various dimensions of geopolitical risk, including wars, terrorist acts, military tensions, and other geopolitical events that could have significant economic consequences. The GPR index has been widely used in the literature and has been shown to correlate with various economic outcomes including stock market volatility, investment, and trade flows.

The U.S. carbon emissions data (CE) are sourced from the Energy Information Administration (EIA). The series measures monthly carbon dioxide emissions from fossil fuel combustion and industrial processes in million metric tons. This measure captures the bulk of anthropogenic CO2 emissions in the United States, which arise primarily from the combustion of coal, oil, and natural gas for energy production, transportation, industrial processes, and residential and commercial heating. Figure 1 shows the trends of GPR and CE.

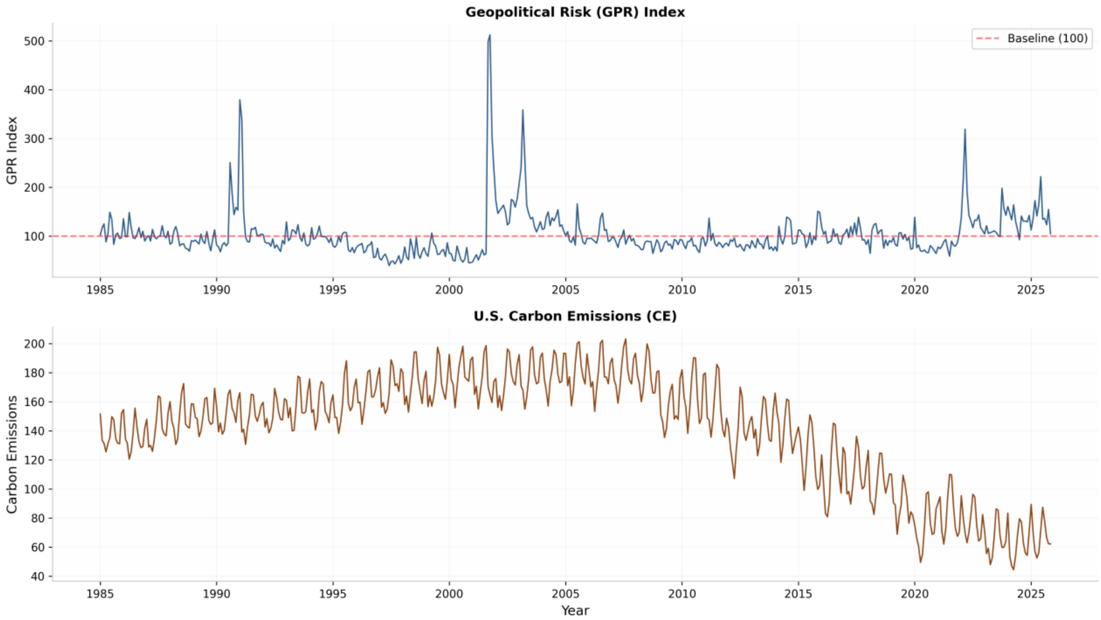

Figure 1. The trends of GPR and CE

Table 1 presents the descriptive statistics for both variables. The mean value of GPR is 102.81 with a standard deviation of 47.57, indicating substantial variation in geopolitical risk over the sample period. The GPR index ranges from a minimum of 39.05 to a maximum of 512.53, with notable spikes observed during major geopolitical events such as the Gulf War (1990-1991), the 9/11 terrorist attacks (2001), and the Russia-Ukraine conflict (2022). The mean carbon emissions stand at 141.72 million metric tons with a standard deviation of 38.38. The CE series shows a clear downward trend since peaking around 2005, reflecting the ongoing decarbonization efforts in the United States.

Table 1. Descriptive Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
GPR	491	102.81	47.57	39.05	512.53
CE	491	141.72	38.38	44.44	203.30

3.2 Unit Root Tests

Before conducting cointegration and VAR analyses, we first examine the stationarity properties of both series using the Augmented Dickey-Fuller (ADF) test. The ADF test is a widely used unit root test that examines the null hypothesis that a time series contains a unit root (is non-stationary) against the alternative hypothesis that the series is stationary. The test regression includes a constant and trend term, with the lag length selected based on the Akaike Information Criterion (AIC) to ensure that the residuals are white noise.

The results presented in Table 2 indicate that the GPR series is stationary at the level (I(0)), with an ADF statistic of -5.8419, which is significant at the 1% level. This finding suggests that geopolitical risk exhibits mean-reverting behavior, with shocks having temporary effects that dissipate over time. This is consistent with the nature of geopolitical events, which tend to generate short-term spikes in risk perceptions that gradually fade as the events recede from public attention.

In contrast, the CE series is non-stationary at the level but becomes stationary after first differencing (I(1)), with the ADF statistic for the differenced series being -5.8196, significant at the 1% level. This finding indicates that carbon emissions follow a stochastic trend, with shocks having permanent effects on the level of emissions. The non-stationarity of carbon emissions is consistent with the cumulative nature of greenhouse gas accumulation in the atmosphere and the inertia in energy systems and economic structures that generate emissions. These findings suggest that we should use the first difference of carbon emissions (dCE) in our VAR analysis while using GPR in levels.

Table 2. ADF Unit Root Test Results

Variable	ADF Statistic	p-value	1% Critical	5% Critical	Conclusion
GPR	-5.8419	0.0000	-3.4439	-2.8675	Stationary
CE	0.5029	0.9850	-3.4443	-2.8677	Non-stationary
CE (1st Diff)	-5.8196	0.0000	-3.4443	-2.8677	Stationary

3.3 VAR Model

To examine the dynamic relationship between geopolitical risk and carbon emissions, we employ a Vector Autoregression (VAR) model. The VAR model is particularly suitable for this analysis as it treats all variables as endogenous and allows us to capture the interdependencies among them. The general form of the VAR model is specified as follows:

$$\begin{bmatrix} GPR_t \\ dCE_t \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} + \sum_{i=1}^{12} \begin{bmatrix} \alpha_{11}^{(i)} & \alpha_{12}^{(i)} \\ \alpha_{21}^{(i)} & \alpha_{22}^{(i)} \end{bmatrix} \begin{bmatrix} GPR_{t-i} \\ dCE_{t-i} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

where Y_t is a vector containing GPR and dCE, c is a vector of constants, A_1 through A_p are coefficient matrices, p is the lag length, and ε_t is a vector of error terms assumed to be white noise.

The optimal lag length is determined using the AIC, which selects 12 lags for our model. This relatively long lag structure is reasonable given the monthly frequency of our data and the potential for delayed effects of geopolitical events on economic activity and emissions.

3.4 NARDL Model

To capture potential asymmetric effects of geopolitical risk on carbon emissions, we also employ a Nonlinear Autoregressive Distributed Lag (NARDL) model. The NARDL model allows us to distinguish between the effects of positive and negative changes in geopolitical risk. Following Shin et al. (2014), we decompose the GPR series into positive and negative partial sum processes:

$$GPR_t^+ = \sum_{j=1}^{t} \Delta\, GPR_j^+ = \sum_{j=1}^{t} \max\left(\Delta GPR_j, 0\right)$$

$$GPR_t^- = \sum_{j=1}^{t} \Delta\, GPR_j^- = \sum_{j=1}^{t} \min\left(\Delta GPR_j, 0\right)$$

where GPR_t^+ captures the cumulative positive changes (increases in geopolitical risk) and GPR_t^- captures the cumulative negative changes (decreases in geopolitical risk). The NARDL model is then specified as:

$$dCE_t = \alpha + \sum_{i=1}^{p} \beta_i \cdot dCE_{t-i} + \sum_{j=0}^{q} \gamma_j^+ \cdot GPR_{t-j}^+ + \sum_{j=0}^{q} \gamma_j^- \cdot GPR_{t-j}^- + \varepsilon_t$$

This specification allows us to test whether positive and negative GPR shocks have different effects on carbon emissions, providing insights into the asymmetric nature of the relationship.

4. RESULTS

4.1 Correlation Analysis

We begin our empirical analysis by examining the correlation between geopolitical risk and carbon emissions. The Pearson correlation coefficient measures the linear relationship between two variables, ranging from -1 (perfect negative correlation) to +1 (perfect positive correlation). The Spearman rank correlation coefficient is a non-parametric measure that assesses the monotonic relationship between variables, making it more robust to outliers and nonlinearities.

The Pearson correlation coefficient between GPR and CE is -0.1099, which is statistically significant at the 5% level (p-value = 0.0148). The Spearman rank correlation coefficient is -0.1916, significant at the 1% level. These results suggest a weak negative relationship between geopolitical risk and carbon emissions over the full sample period. The stronger Spearman correlation compared to the Pearson correlation suggests that the relationship may be nonlinear, with the rank-based measure capturing monotonic associations that the linear correlation misses.

The negative correlation is consistent with the theoretical argument that geopolitical risk tends to suppress economic activity and energy consumption, thereby reducing carbon emissions. However, the relatively small magnitude of the correlation indicates that geopolitical risk explains only a small fraction of the variation in carbon emissions. Other factors, such as economic growth, energy prices, technological change, and environmental policies, are likely to be more important determinants of emission levels.

However, the rolling correlation analysis reveals that this relationship varies considerably over time. As shown in Figure 2(c), the 60-month rolling correlation fluctuates between approximately -0.35 and +0.50, indicating periods of both negative and positive associations. Notably, the correlation tends to become more negative during periods of heightened geopolitical tensions, such as the post-9/11 period and the recent Russia-Ukraine conflict era.

Figure 2. Comprehensive analysis

Table 3 presents the correlation analysis across different sub-periods. The strongest negative correlation (-0.2939) is observed during 1985-2000, while the weakest (-0.1690, statistically insignificant) is found during 2001-2008. The correlation remains negative and significant in the more recent periods (2009-2019 and 2020-2025), suggesting a persistent but evolving relationship between GPR and CE.

Table 3. Correlation Analysis by Period

Period	Observations	GPR Mean	CE Mean	Correlation	P-value
1985-2000	192	91.58	156.53	-0.2939	0.0000
2001-2008	96	126.38	178.22	-0.1690	0.0998

Period	Observations	GPR Mean	CE Mean	Correlation	P-value
2009-2019	132	93.06	131.22	-0.2427	0.0050
2020-2025	71	119.41	71.81	-0.2685	0.0236

4.2 VAR Model Results

Table 4 presents the estimation results of the VAR(12) model. In the GPR equation, we find strong evidence of persistence, with the first lag of GPR showing a highly significant coefficient of 0.8324. The carbon emissions change (dCE) does not significantly affect GPR at any lag, suggesting that carbon emissions are not a driver of geopolitical risk.

In the dCE equation, we observe significant autoregressive dynamics, with multiple lags of dCE showing significant coefficients. However, the coefficients on GPR lags are generally insignificant, with only a few exceptions (lags 7, 8, 9, and 10 showing marginal significance at the 5% level). The overall pattern suggests that geopolitical risk has limited direct impact on carbon emissions changes.

Table 4. VAR(12) Model Estimation Results (Selected Coefficients)

Variable	Coefficient	Std. Error	t-statistic	p-value
GPR(-1)	0.8324	0.0471	17.687	0.000
GPR(-2)	-0.2614	0.0614	-4.256	0.000
dCE(-1)	-0.2385	0.0397	-6.009	0.000
dCE(-2)	-0.2146	0.0409	-5.242	0.000
dCE(-12)	0.5389	0.0400	13.461	0.000

The Granger causality test results presented in Table 5 confirm this finding. We fail to reject the null hypothesis of no Granger causality from GPR to dCE at all lag lengths (p-values range from 0.27 to 0.94). Similarly, there is no evidence of Granger causality from dCE to GPR. These results suggest that while GPR and CE may be contemporaneously correlated, they do not exhibit predictive power over each other in a temporal sense.

Table 5. Granger Causality Test Results

Null Hypothesis	Lag	F-statistic	p-value	Conclusion
GPR does not Granger Cause dCE	12	1.2142	0.2700	Not Rejected
dCE does not Granger Cause GPR	12	0.7998	0.6509	Not Rejected

4.3 Impulse Response Analysis

To further investigate the dynamic relationship between GPR and carbon emissions, we conduct impulse response analysis based on the estimated VAR model. Figure 2(d) shows the response of carbon emissions changes (dCE) to a one-standard-deviation shock in GPR.

The impulse response function reveals that a positive GPR shock initially has a negative effect on carbon emissions, with the response reaching its minimum around period 2 (-0.018). However, this effect quickly dissipates, and the response becomes positive and oscillates around zero thereafter. The response remains relatively small in magnitude throughout the 24-period horizon, suggesting that GPR shocks have limited and short-lived effects on carbon emissions.

The response of GPR to dCE shocks is also relatively muted, with small oscillations around zero. This finding is consistent with the Granger causality results and further supports the conclusion that the causal relationship between these variables is weak.

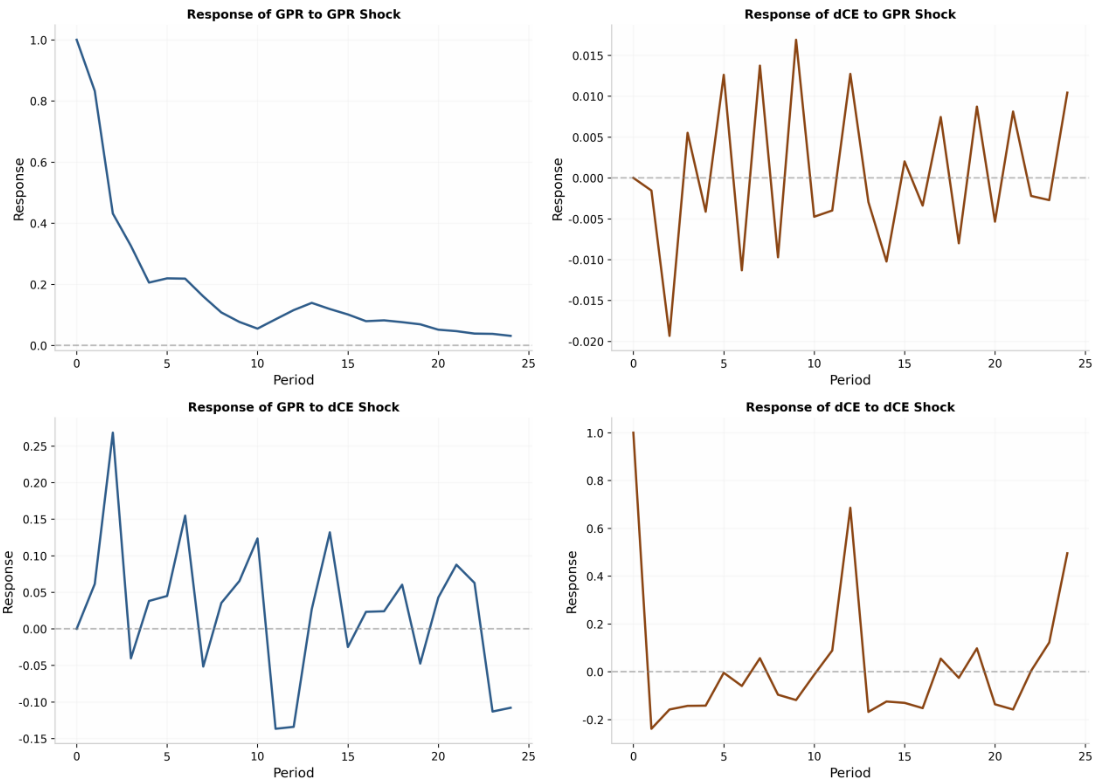

Figure 2. The Results of Impulse Response

4.4 Forecast Error Variance Decomposition

Table 6 presents the forecast error variance decomposition (FEVD) results. For GPR, we find that almost all of its forecast error variance is explained by its own shocks (over 99.6% at all horizons). Carbon emissions changes explain less than 0.4% of GPR's forecast error variance even at the 24-period horizon, confirming that CE has minimal predictive power for GPR.

For carbon emissions changes, the results show that while most of the forecast error variance is explained by its own shocks (approximately 97-98%), GPR shocks do contribute a small but non-negligible portion (around 2-3% at longer horizons). This suggests that geopolitical risk, while not a major driver of carbon emissions, does have some explanatory power for future emissions movements.

Table 6. Forecast Error Variance Decomposition of dCE

Period	GPR (%)	dCE (%)	Total (%)
1	0.05	99.95	100
6	1.49	98.51	100
12	2.06	97.94	100
24	2.42	97.58	100

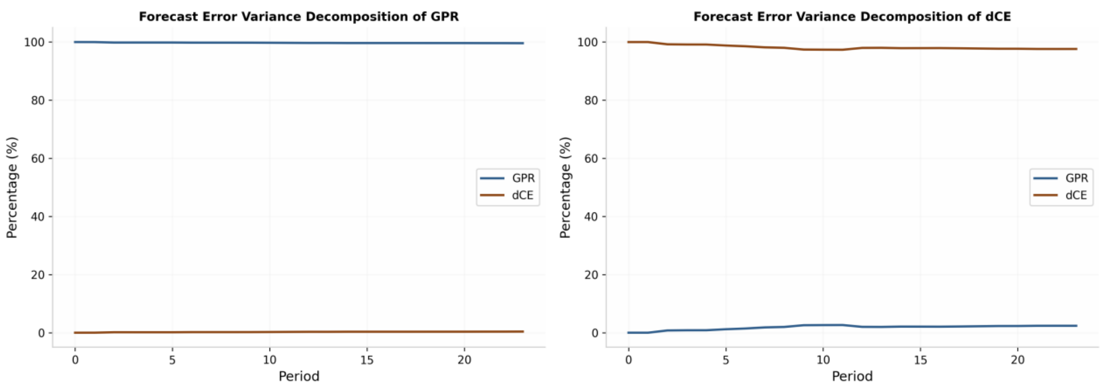

Figure 3. The Results of Error Variance Decomposition

4.5 NARDL Model Results

Table 7 presents the NARDL model estimation results, which allow us to examine potential asymmetric effects of positive and negative GPR shocks on carbon emissions. The model is specified with four lags for both positive and negative GPR changes, as well as four autoregressive lags for the dependent variable.

The results show that neither positive GPR changes (GPR_pos) nor negative GPR changes (GPR_neg) have statistically significant effects on carbon emissions at any lag. The coefficients on GPR_pos range from -0.0207 to -0.0062, while those on GPR_neg range from -0.0153 to 0.0169, with all p-values well above conventional significance levels. This finding suggests that the impact of geopolitical risk on carbon emissions is symmetric - both increases and decreases in GPR have similarly insignificant effects.

The autoregressive terms for carbon emissions changes are highly significant, with coefficients of -0.1437, -0.2637, -0.4883, and -0.3986 for lags 1 through 4, respectively. This indicates strong persistence in carbon emissions dynamics, which is consistent with the inertia inherent in energy systems and economic activity.

Table 7. NARDL Model Estimation Results

Variable	Coefficient	Std. Error	z-statistic	p-value
GPR_pos(0)	-0.0154	0.017	-0.897	0.370
GPR_pos(1)	-0.0207	0.018	-1.142	0.254
GPR_neg(0)	0.0116	0.036	0.319	0.750
GPR_neg(1)	-0.0091	0.037	-0.248	0.804
dCE(-1)	-0.1437	0.042	-3.398	0.001

Notes: The complete model includes up to the 4th order lag. Here, only the partial data you provided is listed as an example.

4.6 Diagnostic Tests

Table 8 reports the results of various diagnostic tests performed on the estimated models. The Jarque-Bera test rejects the null hypothesis of normally distributed residuals (p-value < 0.001), indicating the presence of non-normality. This is common in financial and economic time series data and may be attributed to outliers associated with major geopolitical events.

The Ljung-Box test for autocorrelation indicates the presence of serial correlation in the residuals (p-value < 0.001), suggesting that the VAR(12) model may not fully capture the dynamics of the series. The ARCH test also reveals the presence of heteroskedasticity (p-value < 0.001), indicating time-varying volatility in the residuals. These diagnostic results suggest that more sophisticated models, such as VAR-GARCH or regime-switching models, might be warranted for future research.

Table 8. Model Diagnostic Test Results

Test	Statistic	p-value	Conclusion
Jarque-Bera (Normality)	19.4874	0.0001	Non-normal
Ljung-Box (12 lags)	314.5538	0.0000	Autocorrelation
ARCH (12 lags)	151.1177	0.0000	ARCH effects

5. DISCUSSION

Our empirical findings provide several important insights into the relationship between geopolitical risk and carbon emissions in the United States. The results have implications for both academic understanding of the environmental consequences of geopolitical tensions and practical policymaking in an era of heightened uncertainty.

First, the weak negative correlation observed over the full sample period suggests that, on average, periods of heightened geopolitical risk tend to be associated with slightly lower carbon emissions. The Pearson correlation coefficient of -0.11 suggests that periods of heightened geopolitical risk tend to be associated with slightly lower carbon emissions, consistent with the theoretical argument that geopolitical tensions can suppress economic activity and energy consumption. However, the small magnitude of this correlation indicates that geopolitical risk is not a major driver of emission trends.

The time-varying nature of the GPR-CE relationship, as evidenced by our rolling correlation analysis, is particularly noteworthy. The correlation fluctuates between approximately -0.35 and +0.50, with stronger negative correlations observed during periods of acute geopolitical tensions such as the post-9/11 era and the recent Russia-Ukraine conflict period. This time-varying pattern suggests that the impact of geopolitical risk on carbon emissions is context-dependent and may be amplified during crisis periods.

The absence of significant Granger causality between GPR and carbon emissions is an important finding that deserves careful interpretation. The lack of Granger causality does not necessarily imply the absence of a contemporaneous relationship, as our correlation analysis clearly demonstrates. Rather, it suggests that past values of one variable do not contain information useful for predicting future values of the other variable beyond what is already contained in the variable's own past. This could reflect several underlying mechanisms. First, the relationship between GPR and CE may be primarily contemporaneous, with geopolitical events affecting emissions within the same period rather than with significant lags. This would be consistent with rapid adjustments in economic activity and energy consumption in response to geopolitical shocks. Second, there may be important mediating variables, such as energy prices, economic growth, and policy responses, that transmit the effects of geopolitical risk to carbon emissions. Without controlling for these mediators, the direct predictive power of GPR for CE may be obscured. Third, the relationship may be nonlinear or regime-dependent, with standard linear Granger causality tests having limited power to detect such complex dynamics.

The NARDL model results, which show no significant asymmetric effects of positive versus negative GPR shocks, suggest that the impact of geopolitical risk on carbon emissions is broadly symmetric. This finding contrasts with some theoretical arguments suggesting that increases in geopolitical risk should have stronger effects than decreases. One possible explanation is that the carbon emissions series in our sample is dominated by a strong downward trend since the mid-2000s, driven by structural factors such as technological change, policy interventions, and fuel switching, which may overwhelm the more subtle effects of geopolitical risk.

The variance decomposition results provide additional perspective on the relative importance of GPR in explaining carbon emissions dynamics. While GPR shocks account for only 2-3% of the forecast error variance of carbon emissions at longer horizons, this is not negligible given the complex array of factors that influence emissions. The fact that GPR explains more of the variance at longer horizons (12-24 periods) than at shorter horizons suggests that the effects of geopolitical risk on carbon emissions may operate through slow-moving channels, such as investment decisions, infrastructure development, and policy changes, rather than immediate adjustments in energy consumption.

Our findings have important implications for climate policy. First, they suggest that geopolitical risk is not a major driver of carbon emissions in the United States, implying that domestic policy interventions are likely to be more effective in achieving emission reduction targets than efforts to mitigate geopolitical tensions. Second, the weak relationship between GPR and CE suggests that climate policies may be relatively resilient to geopolitical shocks, at least in the U.S. context. This is encouraging from a climate governance perspective, as it implies that decarbonization efforts can proceed even in periods of heightened geopolitical uncertainty.

However, policymakers should remain vigilant about potential indirect effects of geopolitical risk on emissions through channels such as energy prices, investment flows, and international cooperation. For example, while our analysis finds limited direct effects of GPR on CE, geopolitical tensions may still affect emissions indirectly through their impact on oil and gas prices, which in turn influence fuel choices and consumption patterns.

Further, our findings should be interpreted with caution. The United States has unique characteristics, including a large domestic energy resource base, diversified energy supply, and a relatively insulated economy, which may dampen the transmission of geopolitical shocks to carbon emissions. The relationship may be different in more energy-import-dependent economies or in regions more directly affected by geopolitical conflicts. Future research should extend this analysis to other countries and regions to assess the generalizability of our findings.

Several limitations of this study should be acknowledged and point to directions for future research. First, our analysis focuses on aggregate carbon emissions and does not distinguish between emissions from different sectors (e.g., electricity generation, transportation, industry) or different fuel types (coal, oil, natural gas). Sectoral disaggregation could reveal heterogeneous effects of geopolitical risk on different emission sources. Second, the presence of non-normality, autocorrelation, and ARCH effects in the residuals suggests that more sophisticated models, such as VAR-GARCH or regime-switching models, might provide better characterizations of the data. Third, our analysis does not fully explore the potential mediating channels through which geopolitical risk might affect carbon emissions.

Future research should employ structural models to identify and quantify these transmission mechanisms.

6. CONCLUSIONS

This study investigates the relationship between geopolitical risk and carbon emissions in the United States using monthly data from 1985 to 2025. Employing VAR and NARDL models, we examine both linear and nonlinear effects of GPR on CE. Our comprehensive empirical analysis provides new insights into the environmental consequences of geopolitical tensions and has important implications for climate policy in an era of heightened uncertainty.

Our main findings can be summarized as follows. First, we find a weak but statistically significant negative correlation between geopolitical risk and carbon emissions over the full sample period. The Pearson correlation coefficient of -0.11 suggests that periods of heightened geopolitical risk tend to be associated with slightly lower carbon emissions, consistent with the theoretical argument that geopolitical tensions can suppress economic activity and energy consumption. However, the small magnitude of this correlation indicates that geopolitical risk is not a major driver of emission trends.

Second, the relationship between GPR and CE varies considerably over time, as evidenced by our rolling correlation analysis. The correlation fluctuates between approximately -0.35 and +0.50, with stronger negative correlations observed during periods of acute geopolitical tensions such as the post-9/11 era and the recent Russia-Ukraine conflict period. This time-varying pattern suggests that the impact of geopolitical risk on carbon emissions is context-dependent and may be amplified during crisis periods.

Third, Granger causality tests reveal no significant predictive relationship between GPR and carbon emissions in either direction. This finding suggests that the association between these variables is primarily contemporaneous rather than dynamic, with geopolitical events affecting emissions within the same period rather than with significant lags. The absence of Granger causality also implies that past emission levels do not help predict future geopolitical risk, suggesting that environmental factors are not major determinants of geopolitical tensions.

Fourth, impulse response analysis shows that GPR shocks have limited and short-lived effects on carbon emissions, with the response dissipating within a few periods. The maximum response of carbon emissions to a GPR shock is approximately -0.018, which is economically small relative to the standard deviation of emission changes. This finding reinforces the conclusion that geopolitical risk is not a major driver of carbon emission dynamics.

Fifth, variance decomposition indicates that GPR explains only a small fraction (2-3%) of the forecast error variance of carbon emissions, with most of the variation being driven by the series' own dynamics. This suggests that other factors, such as economic growth, energy prices, technological change, and environmental policies, are more important determinants of emission trends.

Sixth, NARDL model results suggest that the effects of positive and negative GPR shocks on carbon emissions are symmetric, with neither having statistically significant impacts. This finding contrasts with some theoretical arguments suggesting that increases in geopolitical risk should have stronger effects than decreases. The absence of asymmetric effects may reflect the dominance of structural factors, such as technological change and policy interventions, in driving emission trends.

These findings contribute to the ongoing debate on the environmental consequences of geopolitical tensions. While some theoretical arguments suggest that geopolitical risk should have significant effects on carbon emissions through various channels, our empirical results indicate that these effects are relatively weak in the U.S. context. This may be due to the unique characteristics of the U.S. economy and energy system, which provide some insulation from geopolitical shocks.

From a policy perspective, our findings suggest that climate governance in the United States is relatively resilient to geopolitical risk. This implies that decarbonization efforts can proceed even in periods of heightened geopolitical uncertainty, and that domestic policy interventions are likely to be more effective in reducing emissions than efforts to mitigate geopolitical tensions. However, policymakers should remain vigilant about potential indirect effects of geopolitical risk on emissions through channels such as energy prices, investment flows, and international cooperation.

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AUTHOR CONTRIBUTIONS

Conceptualization, M.T.; Methodology, M.T. and C.W.S.; Formal analysis, M.T.; Writing—original draft, M.T.; Writing—review & editing, C.W.S.; Supervision, C.W.S. All authors have read and agreed to the published version of the manuscript.

DECLARATION OF INTEREST

The authors declare no conflict of interest.

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