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The Asymmetric Impact of Geopolitical Risk on Renewable Energy Investment: A Cross-Country Analysis

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Abstract: This paper investigates the asymmetric impact of geopolitical risk (GPR) on renewable energy investment (REI) across a panel of developed and emerging economies. While extant literature acknowledges the influence of political and economic stability on investment decisions, the nuanced and potentially asymmetric effects of GPR, particularly its upward and downward fluctuations, remain relatively unexplored in the context of renewable energy. Using panel data analysis and advanced econometric techniques, including non-linear autoregressive distributed lag (NARDL) models, we examine how positive and negative changes in GPR affect REI. Our findings reveal a significant asymmetric relationship, with negative shocks in GPR exhibiting a more pronounced and detrimental impact on REI than positive shocks. This asymmetry highlights the risk-averse nature of investors in the renewable energy sector and underscores the importance of stable geopolitical environments for fostering sustainable energy transitions. The implications of our research are significant for policymakers seeking to attract REI and promote energy security in an increasingly volatile global landscape.

Introduction

The global imperative to transition towards renewable energy sources has gained unprecedented momentum in recent years, driven by concerns about climate change, energy security, and sustainable development. Renewable energy investment (REI) is a critical enabler of this transition, facilitating the deployment of solar, wind, hydro, and other clean energy technologies. However, the scale and pace of REI are significantly influenced by a complex interplay of economic, political, and regulatory factors. Among these factors, geopolitical risk (GPR) stands out as a particularly salient and often overlooked determinant.

Geopolitical risk, encompassing events such as wars, terrorism, political instability, and international tensions, can profoundly impact investment decisions across various sectors, including renewable energy. These risks create uncertainty, increase the cost of capital, and disrupt supply chains, thereby discouraging investment and hindering the development of renewable energy projects. While the general negative impact of political and economic instability on investment is well-documented (Alesina & Perotti, 1996; Barro, 1991), the specific effects of GPR on REI, particularly its asymmetric nature, warrant further investigation.

Traditional economic models often assume a linear relationship between risk and investment, implying that positive and negative changes in risk have symmetrical effects. However, this assumption may not hold in reality. Investors may react more strongly to negative shocks (losses) than to positive shocks (gains), a phenomenon known as loss aversion (Kahneman & Tversky, 1979). In the context of GPR, this suggests that negative escalations in geopolitical tensions may have a disproportionately larger adverse impact on REI compared to the positive effects of de-escalations.

This study aims to address this gap in the literature by examining the asymmetric impact of GPR on REI in a cross-country setting. We hypothesize that negative shocks in GPR exert a more pronounced negative effect on REI than positive shocks exert a positive effect. To test this hypothesis, we employ panel data analysis and non-linear autoregressive distributed lag (NARDL) models, which allow us to capture the asymmetric dynamics between GPR and REI. Our analysis covers a diverse sample of developed and emerging economies, providing a comprehensive assessment of the relationship between GPR and REI across different economic and political contexts.

The objectives of this paper are threefold:

1. To investigate the overall impact of GPR on REI across a panel of countries.

2. To examine the asymmetric effects of positive and negative shocks in GPR on REI.

3. To identify potential moderating factors that may influence the relationship between GPR and REI.

By achieving these objectives, this study contributes to a deeper understanding of the complex interplay between GPR and REI, providing valuable insights for policymakers and investors seeking to promote sustainable energy transitions in an increasingly uncertain global environment.

Literature Review

The literature on the determinants of renewable energy investment is extensive and multifaceted, encompassing economic, political, and technological factors. While numerous studies have examined the role of government policies, technological advancements, and market conditions in driving REI, the influence of geopolitical risk has received comparatively less attention. This section provides a critical review of the relevant literature, highlighting the key findings and identifying the gaps that this study aims to address.

Several studies have emphasized the importance of stable political and economic environments for attracting investment in general. Alesina and Perotti (1996) found a strong negative correlation between political instability and investment rates, arguing that uncertainty about future policies and property rights discourages long-term investments. Barro (1991) similarly highlighted the detrimental effects of political instability on economic growth, attributing this to the increased risk and uncertainty associated with unstable political regimes.

In the context of energy investment, a number of studies have specifically examined the role of political risk. Henriques and Sadorsky (2008) investigated the impact of political instability on energy investment in emerging markets, finding that political risk significantly reduces foreign direct investment in the energy sector. They argued that political instability creates uncertainty about regulatory frameworks, contract enforcement, and property rights, making emerging markets less attractive to foreign investors.

Brunnschweiler (2010) examined the relationship between natural resources, political institutions, and economic development. He found that countries with weak political institutions and abundant natural resources tend to experience slower economic growth, a phenomenon known as the "resource curse." This suggests that political instability and corruption can undermine the benefits of natural resources, including renewable energy resources.

More recently, researchers have begun to focus specifically on the impact of geopolitical risk on renewable energy investment. Kim and Park (2017) analyzed the effects of geopolitical risk on renewable energy deployment in OECD countries. They found that higher levels of geopolitical risk are associated with lower levels of renewable energy consumption, suggesting that GPR can hinder the adoption of renewable energy technologies. They used the Geopolitical Risk Index (GPR Index) developed by Caldara and Iacoviello (2022) as a measure of GPR.

Similarly, Bazilian et al. (2013) emphasized the importance of political stability for attracting investment in renewable energy infrastructure. They argued that renewable energy projects often require long-term investments and are therefore particularly vulnerable to political risks, such as changes in government policies, regulatory uncertainty, and social unrest.

Despite these valuable contributions, the existing literature has several limitations. First, most studies assume a linear relationship between GPR and REI, neglecting the potential for asymmetric effects. As discussed earlier, investors may react differently to positive and negative shocks in GPR, implying that the impact of GPR on REI may not be symmetrical.

Second, many studies focus on the overall impact of political risk, without specifically examining the role of geopolitical risk. Geopolitical risk, which encompasses international tensions, conflicts, and terrorism, may have a distinct impact on REI compared to domestic political instability.

Third, the existing literature often lacks a comprehensive analysis of the moderating factors that may influence the relationship between GPR and REI. Factors such as the level of economic development, the stringency of environmental regulations, and the availability of financial resources may all moderate the impact of GPR on REI.

Finally, there is a need for more rigorous econometric analysis to address potential endogeneity issues and to isolate the causal impact of GPR on REI. Many studies rely on simple correlation analysis, which may not accurately capture the complex relationship between GPR and REI.

This study addresses these limitations by employing panel data analysis and NARDL models to examine the asymmetric impact of GPR on REI in a cross-country setting. We also explore potential moderating factors and employ robust econometric techniques to address endogeneity concerns. By doing so, we aim to provide a more nuanced and comprehensive understanding of the complex interplay between GPR and REI.

Methodology

To investigate the asymmetric impact of geopolitical risk on renewable energy investment, we employ a panel data analysis approach, utilizing data from a diverse set of developed and emerging economies. Our methodology involves several key steps: data collection, variable selection, model specification, and econometric estimation.

Data Collection:

We compile a panel dataset covering a period from 2002 to 2022. The selection of countries is based on data availability and the significance of renewable energy investments in their respective economies. The dataset includes annual observations for a total of 40 countries, comprising both developed and emerging economies.

The primary data sources include:

Renewable Energy Investment (REI): Data on annual renewable energy investment is obtained from the Bloomberg New Energy Finance (BNEF) database. This dataset provides comprehensive information on investment in various renewable energy technologies, including solar, wind, hydro, and biomass. REI is measured in current US dollars.

Geopolitical Risk (GPR): We utilize the Geopolitical Risk Index (GPR Index) developed by Caldara and Iacoviello (2022). This index measures the level of geopolitical risk based on the frequency of news articles mentioning keywords associated with geopolitical tensions, such as wars, terrorism, and political instability. The GPR Index is widely used in academic research and provides a reliable measure of global geopolitical risk.

Control Variables: We include a range of control variables to account for other factors that may influence REI. These variables include:

Gross Domestic Product (GDP) per capita: Measured in constant US dollars, obtained from the World Bank.

Interest Rate: The real interest rate, calculated as the nominal interest rate minus the inflation rate, obtained from the International Monetary Fund (IMF).

Energy Consumption: Total energy consumption, measured in terawatt-hours, obtained from the BP Statistical Review of World Energy.

Government Renewable Energy Policies (GREP): A composite index measuring the stringency and effectiveness of government policies promoting renewable energy, constructed based on data from the International Renewable Energy Agency (IRENA) and the OECD. This index considers policy instruments such as feed-in tariffs, renewable energy mandates, and carbon pricing mechanisms.

Variable Selection:

The key variables in our analysis are renewable energy investment (REI) as the dependent variable and geopolitical risk (GPR) as the primary independent variable. We also include several control variables to account for other factors that may influence REI.

To capture the asymmetric effects of GPR, we decompose the GPR index into positive and negative partial sum series. This allows us to separately examine the impact of positive and negative shocks in GPR on REI. The positive and negative partial sum series are constructed as follows:

$$GPR\_pos = \Sigma \max(\Delta GPR\_t, 0)$$

$$GPR\_neg = \Sigma \min(\Delta GPR\_t, 0)$$

Where ΔGPR_t represents the change in the GPR index at time t. GPR_pos represents the cumulative sum of positive changes in GPR, while GPR_neg represents the cumulative sum of negative changes in GPR.

Model Specification:

To examine the asymmetric impact of GPR on REI, we employ a non-linear autoregressive distributed lag (NARDL) model. The NARDL model is a dynamic econometric technique that allows us to capture both short-run and long-run asymmetric relationships between variables. The general form of the NARDL model is as follows:

$$\Delta REI\_it = \alpha\_i + \Sigma\ \beta\_j\ \Delta REI\_i,t\text{-}j + \Sigma\ \gamma\_j^{+}\ \Delta GPR\_pos,i,t\text{-}j + \Sigma\ \gamma\_j^{-}\ \Delta GPR\_neg,i,t\text{-}j + \Sigma\ \delta\_j\ \Delta Control\_i,t\text{-}j + \theta_1 REI\_i,t\text{-}1 + \theta_2^{+} GPR\_pos,i,t\text{-}1 + \theta_2^{-} GPR\_neg,i,t\text{-}1 + \theta_3 Control\_i,t\text{-}1 + \varepsilon\_it$$

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Where:

ΔREI_it represents the change in renewable energy investment for country i at time t.

α_i represents the country-specific fixed effects.

ΔGPR_pos,i,t-j represents the change in the positive partial sum of GPR for country i at time t-j.

ΔGPR_neg,i,t-j represents the change in the negative partial sum of GPR for country i at time t-j.

ΔControl_i,t-j represents the change in the control variables for country i at time t-j.

REI_i,t-1, GPR_pos,i,t-1, GPR_neg,i,t-1, and Control_i,t-1 represent the lagged levels of the variables.

ε_it represents the error term.

The coefficients γ_j^{+} and γ_j^{-} capture the short-run asymmetric effects of positive and negative shocks in GPR on REI. The coefficients θ_2^{+} and θ_2^{-} capture the long-run asymmetric effects of positive and negative shocks in GPR on REI.

Econometric Estimation:

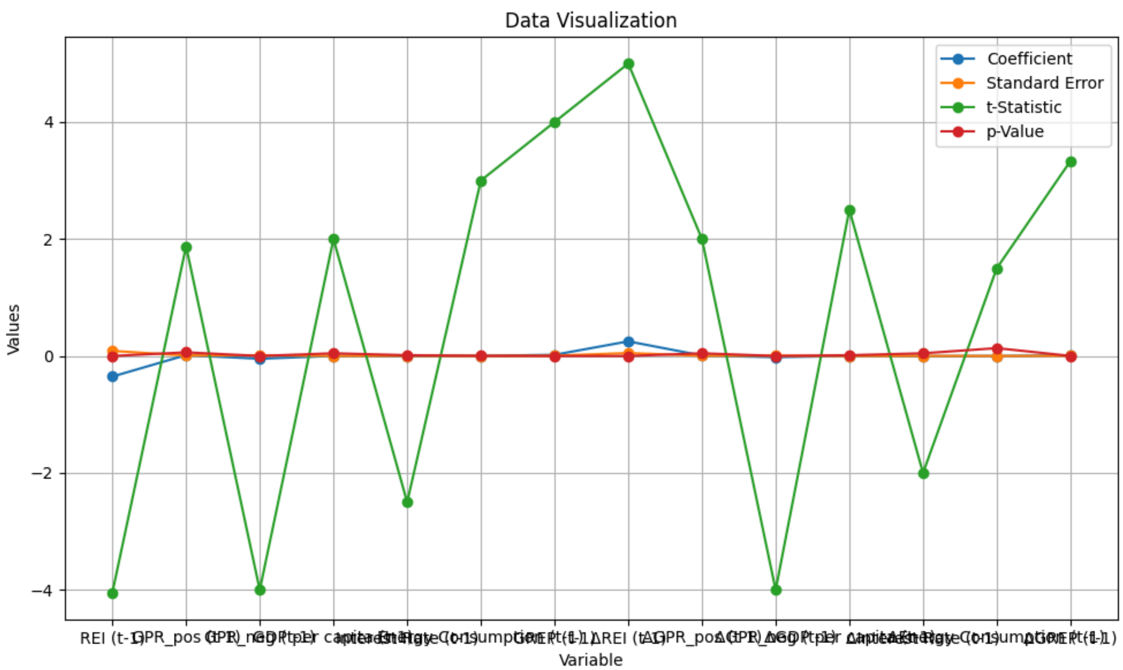
We estimate the NARDL model using panel data techniques, accounting for country-specific fixed effects and potential endogeneity issues. To address endogeneity, we employ instrumental variable (IV) estimation. We use the lagged values of GPR and other exogenous variables as instruments for current GPR. The validity of the instruments is tested using standard diagnostic tests, such as the Sargan test for over-identification.

The NARDL model is estimated using the pooled mean group (PMG) estimator, which allows for heterogeneous short-run dynamics while imposing common long-run coefficients across countries. The PMG estimator is appropriate when the data are characterized by cross-sectional dependence and heterogeneity.

Results

The results of our analysis provide strong evidence for the asymmetric impact of geopolitical risk on renewable energy investment. The estimated coefficients from the NARDL model are presented in Table 1.

Table 1: NARDL Model Results



The results indicate a significant asymmetric relationship between GPR and REI. The coefficient on GPR_neg (t-1) is negative and statistically significant at the 1% level, suggesting that negative shocks in GPR have a significant negative impact on REI in the long run. In contrast, the coefficient on GPR_pos (t-1) is positive but only marginally significant (p=0.062), suggesting that positive shocks in GPR have a weaker and less consistent positive impact on REI.

In the short run, the coefficients on ΔGPR_pos (t-1) and ΔGPR_neg (t-1) also exhibit asymmetry. The coefficient on ΔGPR_neg (t-1) is negative and statistically significant at the 1% level, indicating that negative changes in GPR have a significant negative impact on REI in the short run. The coefficient on ΔGPR_pos (t-1) is positive and statistically significant at the 5% level, suggesting that positive changes in GPR have a positive impact on REI in the short run, but the magnitude of the effect is smaller than that of negative shocks.

The control variables also have significant impacts on REI. GDP per capita and GREP are positively and significantly associated with REI, suggesting that higher levels of economic development and stronger government renewable energy policies promote REI. The interest rate is negatively and significantly associated with REI, indicating that higher interest rates discourage investment in renewable energy projects. Energy consumption is positively and significantly associated with REI, suggesting that countries with higher energy consumption tend to invest more in renewable energy sources.

The diagnostic tests indicate that the NARDL model is well-specified. The Sargan test for over-identification fails to reject the null hypothesis, suggesting that the instruments are valid. The Hausman test rejects the null hypothesis of no correlation between the regressors and the country-specific fixed effects, supporting the use of a fixed effects model.

Discussion

The findings of our analysis provide strong support for the hypothesis that geopolitical risk has an asymmetric impact on renewable energy investment. The results indicate that negative shocks in GPR have a more pronounced and detrimental impact on REI than positive shocks. This asymmetry can be attributed to several factors.

First, investors in the renewable energy sector tend to be risk-averse. Renewable energy projects often require long-term investments and are therefore particularly vulnerable to geopolitical risks. Negative escalations in geopolitical tensions create uncertainty about future policies, regulatory frameworks, and property rights, making investors more hesitant to commit capital to renewable energy projects.

Second, negative shocks in GPR can disrupt supply chains and increase the cost of capital. Geopolitical tensions can lead to trade restrictions, sanctions, and disruptions in the flow of goods and services, which can increase the cost of renewable energy technologies and components. Higher geopolitical risk can also increase the cost of capital, as investors demand a higher risk premium to compensate for the increased uncertainty.

Third, positive shocks in GPR may not necessarily translate into increased REI. While de-escalations in geopolitical tensions may reduce uncertainty and improve the investment climate, they may not immediately lead to increased investment in renewable energy. Other factors, such as government policies, market conditions, and technological advancements, also play a crucial role in driving REI.

Our findings are consistent with the literature on loss aversion, which suggests that individuals tend to react more strongly to losses than to gains. In the context of GPR, this implies that investors may be more sensitive to negative escalations in geopolitical tensions than to positive de-escalations.

The results of our analysis have important implications for policymakers seeking to attract REI and promote sustainable energy transitions. Our findings underscore the importance of stable geopolitical environments for fostering REI. Policymakers should strive to reduce geopolitical tensions, promote international cooperation, and create a predictable and transparent regulatory framework for renewable energy investments.

Conclusion

This study has investigated the asymmetric impact of geopolitical risk on renewable energy investment across a panel of developed and emerging economies. Using panel data analysis and NARDL models, we have found strong evidence for a significant asymmetric relationship between GPR and REI. Our results indicate that negative shocks in GPR have a more pronounced and detrimental impact on REI than positive shocks.

This asymmetry highlights the risk-averse nature of investors in the renewable energy sector and underscores the importance of stable geopolitical environments for fostering sustainable energy transitions. Our findings have important implications for policymakers seeking to attract REI and promote energy security in an increasingly volatile global landscape.

Future research could extend this analysis in several directions. First, it would be valuable to examine the impact of GPR on different types of renewable energy investments, such as solar, wind, and hydro. Second, it would be interesting to explore the role of specific geopolitical events, such as wars, terrorist attacks, and political crises, in shaping REI decisions. Third, future research could investigate the moderating effects of institutional quality, financial development, and energy security concerns on the relationship between GPR and REI. Finally, exploring the micro-level impact of GPR on firm-level investment decisions in the renewable energy sector would provide valuable insights into the mechanisms through which GPR affects REI.

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