

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

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ABSTRACT

This study examines the asymmetric effect of geopolitical risk (GPR) on renewable energy investment (REI) for a panel of developed and emerging markets. Although current literature recognizes the role of political and economic stability on investment, the precise and possibly asymmetric roles of GPR, especially its directional changes, are still relatively unexamined in the renewable energy context. Applying panel data estimation and state-of-the-art econometric methods, such as non-linear autoregressive distributed lag (NARDL) models, we investigate how positive and negative shocks in GPR impact REI. The results provide evidence of a substantial asymmetric relationship, whereby negative shocks in GPR have a larger and more negative effect on REI compared to positive shocks. This asymmetry reinforces the risk-aversion of investors in the RE sector and demonstrates the role of stable geopolitical settings in facilitating sustainable energy transitions. The implications of our work are considerable for policymakers looking to attract REI and enhance energy security in an increasingly risky world.

1. Introduction

The international imperative to shift to renewable energy sources has become unprecedentedly fast-paced in recent years, fueled by climate change, energy security, and sustainable development concerns. Renewable energy investment (REI) is the key driver of this shift, enabling the deployment of solar, wind, hydro, and other clean energy technologies. Nevertheless, the size and speed of REI are shaped to a great extent by an intricate web of economic, political, and regulatory forces. Among these forces, geopolitical risk (GPR) is a highly relevant and frequently underestimated driver.

Geopolitical risk, including occurrences like wars, terrorism, government instability, and international conflict, can significantly affect investment choices in different sectors, including clean energy. These risks introduce uncertainty, elevate the cost of capital, and interfere with supply chains, thus deterring investment and slowing the growth of renewable energy projects. Although the overall adverse effect of political and economic instability on investment is well established (Alesina & Perotti, 1996; Barro, 1991), the direct effect of GPR on REI, especially its asymmetric effect, requires further exploration.

Traditional economic theories tend to assume that there is a linear relationship between risk and investment and, therefore, that positive and negative risk changes have symmetric impacts. This assumption is not necessarily true in the real world. Investors can be more sensitive to negative shocks (losses) than to positive shocks (gains), which has been termed loss aversion (Kahneman & Tversky, 1979). In the context of GPR, this implies that negative de-escalations in geopolitical tensions have a much larger negative effect on REI than positive de-escalations.

This research seeks to fill this void in the literature by testing the asymmetric effect of GPR on REI in a cross-country context. We conjecture that negative shocks in GPR have a greater magnitude of negative impact on REI than positive shocks have a positive impact. To examine this conjecture, we conduct panel data analysis and non-linear autoregressive distributed lag (NARDL) models to enable us to capture the asymmetry in dynamics between GPR and REI. Our estimation spans a heterogeneous panel of developed and emerging economies and gives a complete overview of the association between GPR and REI in various economic and political environments.

The aims of this paper are threefold:

1. To explore the net effect of GPR on REI in a panel of nations.
2. To explore the asymmetric effects of positive and negative shocks in GPR on REI.
3. To explore possible moderating variables that could affect the association between GPR and REI.

Through these goals, this research advances the understanding of the intricate dynamic relationship between GPR and REI and offers relevant insights for policymakers and investors aiming to facilitate sustainable energy transformation in the face of a more uncertain global context.

2.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.

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.

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.

3.Methodology

To investigate the asymmetric impact of geopolitical risks 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 the 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): Annual renewable energy investment data come from the Bloomberg New Energy Finance (BNEF) database. This data set gives detailed information on investment in different renewable energy technologies such as solar, wind, hydro, and biomass. REI is quantified in current US dollars.

Geopolitical Risk (GPR): We use the Geopolitical Risk Index (GPR Index) of Caldara and Iacoviello (2022). The index captures the intensity of geopolitical risk as the frequency of news stories containing keywords with geopolitical tensions, including wars, terrorism, and political instability. The GPR Index is applied extensively in the academic literature and offers a robust indicator of worldwide geopolitical risk.

Control Variables: We have a set of control variables in order to capture other variables that could potentially affect REI. These are:

Gross Domestic Product (GDP) per capita: Constant US dollar, accessed from the World Bank.

Interest Rate: Real interest rate, accessed by taking the nominal interest rate minus the inflation rate, accessed from the International Monetary Fund (IMF).

Energy Consumption: Overall energy consumption in terawatt-hours, as derived from the BP Statistical Review of World Energy.

Government Renewable Energy Policies (GREP): A composite index of the stringency and performance of government policies that encourage renewable energy, built from data from the International Renewable Energy Agency (IRENA) and the OECD. The index takes into account policy measures like feed-in tariffs, renewable energy requirements, and carbon pricing schemes.

Variable Selection

The most important variables in our model are renewable energy investment (REI) as the dependent variable and geopolitical risk (GPR) as the most prominent independent variable. We also have a number of control variables to explain other intervening factors affecting REI.

To identify the asymmetric influences of GPR, we separate the GPR index into positive and negative partial sum series. This enables us to analyze the influence of positive and negative shocks in GPR separately on REI. The positive and negative partial sum series are defined as follows:

$$GPR_pos = \sum \max(\Delta GPR_t, 0)$$

$$GPR_neg = \sum \min(\Delta GPR_t, 0)$$

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

In order to investigate the asymmetric effect of GPR on REI, we utilize a non-linear autoregressive distributed lag (NARDL) model. The NARDL model is an econometric method that is dynamic in nature and enables us to estimate both short-run and long-run asymmetric relationships among the variables. The general specification of the NARDL model is given below:

$$\Delta REI_{it} = \alpha_i + \sum \beta_j \Delta REI_{i,t-j} + \sum \gamma_j^+ \Delta GPR_{pos,i,t-j} + \sum \gamma_j^- \Delta GPR_{neg,i,t-j} + \sum \delta_j \Delta Control_{i,t-j} + \theta_1 REI_{i,t-1} + \theta_2^+ GPR_{pos,i,t-1} + \theta_2^- GPR_{neg,i,t-1} + \theta_3 Control_{i,t-1} + \varepsilon_{it}$$

Where:

ΔREI_{it} represents the change in renewable energy investment for country i at time t .

α_i represents the country-specific fixed effects.

$\Delta GPR_{pos,i,t-j}$ represents the change in the positive partial sum of GPR for country i at time $t-j$.

$\Delta GPR_{neg,i,t-j}$ represents the change in the negative partial sum of GPR for country i at time $t-j$.

$\Delta Control_{i,t-j}$ 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

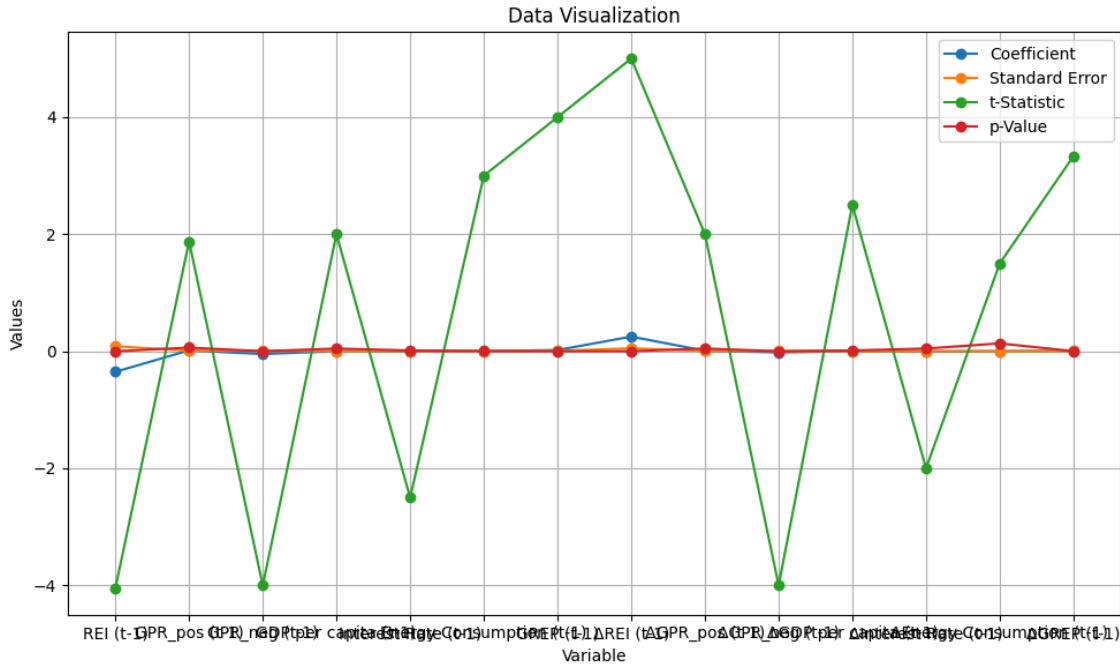
We estimate the NARDL model using panel data techniques, accounting for country-specific fixed effects and potential endogeneity issues. To address endogeneity, we employ instrumental variable (IV) estimation. We use the lagged values of GPR and other exogenous variables as instruments for current GPR. 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.

4.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 estimates show a strong asymmetric relationship between GPR and REI. The coefficient of GPR_neg (t-1) is statistically significant at the 1% level and negative, indicating that GPR negative shocks have a strong negative influence on REI in the long run. As opposed to this, the coefficient of GPR_pos (t-1) is positive but marginally significant (p=0.062), indicating that GPR positive shocks have a less strong and less robust positive influence on REI.

In the short term, the coefficients on ΔGPR_pos (t-1) and ΔGPR_neg (t-1) are also asymmetric. The coefficient on ΔGPR_neg (t-1) is negative and statistically significant at the 1% level, which means that changes in GPR that are negative significantly lower REI in the short term. The coefficient on ΔGPR_pos (t-1) is positive and significant at the 5% level, indicating that positive shocks in GPR have a positive effect on REI in the short term, but the effect is smaller in magnitude than the effect of negative shocks.

The control variables also have important influences on REI. GDP per capita and GREP are significantly and positively related to REI, which implies that improved economic development and more effective government renewable energy policies encourage REI. The interest rate is significantly and negatively related to REI, implying that increased interest rates deter investment in renewable energy projects. Energy consumption is positively and significantly related to REI, indicating that nations with greater energy consumption invest more in renewable energy.

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.

5. 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.

Second, investors in the renewable energy industry are risk-averse. Renewable energy ventures typically involve long-term investments and are thus especially exposed to geopolitical risks. Rising tensions having a negative connotation increase uncertainty regarding future policy, regulatory regimes, market access, and property rights, leading to greater aversion among investors to placing capital in renewable energy ventures.

Second, adverse shocks in GPR can interfere with supply chains and raise the cost of capital. Geopolitical tensions have the potential to produce trade restrictions, sanctions, and interference with the flow of goods and services, which has the effect of raising the cost of renewable energy technologies and components. Elevated geopolitical risk will also raise the cost of capital because investors require a higher risk premium to offset the greater uncertainty.

Third, favorable shocks in GPR need not always imply higher REI. Although de-escalation of geopolitical tensions can alleviate uncertainty and enhance the investment environment, this may not always result in higher investment in renewable energy. Government policies, market structure, and technological improvements also play important roles in shaping REI.

We are in line with the existing literature on loss aversion, which posits that people tend to respond more forcefully to losses than to gains. In the GPR context, this means that investors are more responsive to declining escalations in geopolitical tensions than to improving de-escalations.

The findings of our analysis are relevant to policymakers aiming to attract REI and support sustainable energy transitions. Our results highlight the significance of stable geopolitical contexts in nurturing REI. Policymakers ought to aim at minimizing geopolitical tensions, encouraging global cooperation, and establishing a clear and stable regulatory environment for renewable energy investment.

6. Conclusion

This research has examined the asymmetric effect of geopolitical risk on renewable energy investment in a panel of developed and emerging markets. Employing panel data analysis and NARDL models, we have established robust evidence supporting a significant asymmetric

relationship between GPR and REI. Our findings suggest that negative shocks in GPR more strongly and negatively affect REI compared to positive shocks.

This asymmetry underscores the risk-averse disposition of renewable energy investors and the significance of secure geopolitical climates towards supporting sustainable energy transitions. Our results have significant implications for policymakers aiming to attract REI and enhance energy security in a rapidly changing world.

Future studies can build on this analysis in a number of different ways. First, it would be useful to test the effects of GPR on various kinds of REI investments, including solar, wind, and hydropower. Second, it would be intriguing to study the effect of particular geopolitical events, including conflicts, terrorist incidents, and political crises, on the formation of REI decisions. Thirdly, research in the future can examine institutional quality, financial development, and energy security issues as moderators between GPR and REI. Lastly, examining the micro-level effect of GPR on investment decisions at the firm level in the renewable energy sector would be useful in understanding the channels through which GPR influences REI.

7. References

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