International Journal of Innovative Research and Scientific Studies, 8(3) 2025, pages: 3079-3088

IJIRSS
International Journal of Innovative Research & Scientific Studies

ISSN: 2617-6548

URL: www.ijirss.com

Assessing the impact of geopolitical risks on renewable energy transitions - an empirical study in the Asia-Pacific Region

Tran Thi Thu Huong[1*], Hoang Tham Quyen[2]

[1,2]Banking Academy of Vietnam, 12 Chua Boc, Dong Da, Ha Noi, Vietnam.

Corresponding author: Tran Thi Thu Huong (*Email: tranhuong@hvnh.edu.vn*)

Abstract

This study examines the impact of geopolitical risks (GPR) on renewable energy adoption in the Asia-Pacific region, focusing on how adverse geopolitical events influence the transition to renewable energy. Using panel regression models, including fixed effects, random effects, and Generalized Least Squares (GLS), the study analyzes data from a group of Asia-Pacific countries between 2000 and 2021. The findings reveal a positive impact of geopolitical risks on renewable energy consumption, with political instability and international conflicts encouraging countries to shift towards renewable energy sources to enhance energy security and reduce dependence on imported fossil fuels. Additionally, macroeconomic factors such as financial sector development, inflation, government expenditure, trade, and CO2 emissions also significantly affect renewable energy adoption. The study concludes that geopolitical risks, while posing challenges, offer opportunities for promoting renewable energy, and suggests that policymakers should focus on strategies to mitigate these risks, incentivize renewable energy investments, promote green finance, and foster technological innovation to reduce fossil fuel reliance. The research emphasizes the need for international cooperation and robust financial systems to support energy transitions in the context of geopolitical instability.

Keywords: Geopolitical risk, Renewable energy transition.

DOI: 10.53894/ijirss.v8i3.7168
Funding: This research is supported by the Banking Academy of Vietnam, Vietnam (Grant Number: 4990/TB-HVNH). We are grateful for their financial support which made this study possible.
History: Received: 28 March 2025 / **Revised:** 1 May 2025 / **Accepted:** 3 May 2025 / **Published:** 19 May 2025

Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: Both authors contributed equally to the conception and design of the study. Both authors have read and agreed to the published version of the manuscript.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Publisher: Innovative Research Publishing

1. Introduction

In the context of increasingly severe climate change and energy security becoming a global concern, the transition from fossil fuels to renewable energy has emerged as a strategic priority in the development policies of many countries. The initial driving force for the energy transition was mainly environmental and economic objectives. However, geopolitical factors have increasingly played a dominant role in this process in recent years.

The world is witnessing a rapid increase in geopolitical conflicts, from the Russia-Ukraine war, Israel-Palestine tensions, to disputes in the East Asia region, which have profoundly changed the global energy market landscape in terms of both supply and price. These "black swan" events not only cause political instability but also create major economic shocks, especially in the energy sector. Geopolitical Risk (GPR), including armed conflicts, political instability, trade disputes, and policy changes, has become a key factor disrupting the global energy supply chain, leading to energy price fluctuations and making it difficult for policymaking and investment decisions.

The ongoing tensions between Russia and Ukraine have disrupted fossil fuel supply chains, reduced industrial output, and pushed global energy prices to record levels. With fossil fuels still accounting for more than 70% of global CO_2 emissions, climate-related disasters and energy security concerns are becoming important drivers of the transition to clean energy. Over the past three decades, the world has witnessed a series of regional crises, such as the war in Yemen in 2014 and the diplomatic tensions in Qatar in 2017, disrupting energy flows and forcing countries to diversify their energy mix to ensure national security.

According to the IEA [1] global investment in renewable energy will reach a record $1.7 trillion in 2022, thanks to a strong recovery from the COVID-19 pandemic and the current energy crisis. Comparing 2023 data with 2021 data, annual investment in renewable energy projects increased by 24%, significantly higher than the 15% increase in the traditional energy sector. In particular, the Ukraine crisis and tensions in the Gulf region are driving countries to accelerate the energy transition to reduce dependence on fossil fuels. The European Union (EU), which is urgently decreasing its reliance on imported gas from Russia, has increased its renewable energy development target and adjusted its forecast for additional capacity by 40% compared to the pre-war period [2].

Many countries have also committed to achieving net-zero emissions in the coming decades, and to fulfill this commitment, governments have invested heavily in renewable energy infrastructure. In this context, geopolitical shocks not only pose challenges but also open up opportunities to reshape the global energy system toward a more sustainable and resilient direction.

This study aims to analyze the role of geopolitical shocks in shaping renewable energy use in countries in the Asia-Pacific region. Specifically, the Geopolitical Risk (GPR) index developed by Caldara and Iacoviello [3] is integrated into the analytical model to assess the impact of geopolitical uncertainties on the energy transition. The paper is structured into four parts: after part 1, there is an introduction; part 2 reviews studies on the impact of geopolitical risks on the renewable energy transition; Section 3 provides an empirical analysis of the impact of geopolitical risks in Asia-Pacific countries; finally, Section 4 provides specific policy implications and recommendations.

2. Literature Review

Over the past two decades, academic interest in the factors that promote or hinder renewable energy development has increased significantly. Many studies have shown that the spread of clean energy is governed by various economic, environmental, political, institutional, and demographic factors. However, empirical results remain inconsistent, mainly due to differences in analytical methods and sample characteristics.

On the economic side, some studies [4, 5] suggest that high income promotes clean energy development, while others [6, 7] find a negative or insignificant relationship. One explanation for this difference is the threshold effect: when income levels exceed a certain threshold, energy demand increases so rapidly that renewable energy cannot meet it immediately, leading to a relative decline in utilization rates.

Financial factors such as financial development and financial inclusion have also received attention. Wang et al. [8] and Chang et al. [9] show that improved access to finance can promote clean energy investment, although the effects of these factors may vary across income groups. Financial development, measured by the domestic credit index to the private sector, is also an important driver of renewable energy investment. Levine [10] and Islam et al. [11] both argue that a developed financial system will reduce the cost of capital, improve access to long-term capital, and promote green energy investment. Furuoka [12] provides evidence in Asian countries that financial development not only supports economic growth but also has a direct positive impact on renewable energy consumption. In contrast, in countries with underdeveloped financial systems, implementing clean energy projects often faces many difficulties due to inadequate funding mechanisms.

The transition to renewable energy has become one of the top priorities in countries' sustainable development strategies. One factor that cannot be ignored in promoting or hindering this process is the flow of foreign direct investment (FDI). Empirical studies show that FDI plays a significant role in promoting clean technology transfer, especially for developing countries. Lee [13] points out that FDI can increase clean energy use while supporting economic growth and reducing CO_2 emissions. However, this relationship is not always linear and straightforward. Liu et al. [14] note that without strict environmental control mechanisms, FDI can be accompanied by negative consequences, leading to increased emissions and environmental pollution in the host country, consistent with the "pollution haven hypothesis." In emerging economies, differences in FDI policy design can create significant divergence in outcomes for the energy transition.

In addition to the role of FDI, international trade is an important channel that promotes or hinders the energy transition. Saidi and Hammami [15] assert that trade integration helps countries access new renewable energy technologies more quickly, improving energy efficiency and reducing CO_2 emissions. Bellakhal,= et al. [16] also demonstrate that trade positively impacts renewable energy investment in MENA countries. However, Nasreen and Anwar [17] argue that in some cases, increased trade, especially fossil fuel trade, can lead to increased conventional energy consumption and delay the green transition. Therefore, the effect of trade on the energy transition is two-sided, depending on each country's import-export structure and its trade-environment policy orientation.

Inflation is also a macroeconomic factor that strongly influences the energy transition. In the context of high inflation, investment costs for renewable energy projects are often pushed up due to rising interest rates, increasing raw material costs, and shrinking long-term investment flows. Abdullah, et al. [18] emphasize that a stable economic environment with low inflation is a favorable condition for promoting investments in the green energy sector. Meanwhile, Baker et al. [19] developed the Economic Policy Uncertainty (EPU) index, showing that macroeconomic instability associated with volatile inflation can reduce investment levels in renewable energy. In particular, high inflation and policy uncertainty in emerging markets also increase investment risks, leading both international and domestic investors to be hesitant about projects requiring long payback periods, such as renewable energy.

GDP growth has always been closely linked to energy demand. Sadorsky [20] shows that in emerging countries, economic growth often leads to higher energy consumption, primarily based on fossil fuels. However, Bhattacharya et al. [21] found that countries with high economic growth rates are also able to adopt renewable energy technologies more quickly if supported by appropriate policies. From this, it can be seen that economic growth does not necessarily contradict energy transition, but can support each other if development policies are designed towards sustainability.

Government spending plays a crucial role in supporting the development of renewable energy. Keynes [22] emphasized the importance of public investment in stimulating new economic sectors, especially in the context of free markets being cautious about risky sectors such as renewable energy. Recent studies also confirm thisADB [23] and International Finance Corporation (IFC) [24] argue that public resources, especially green finance programs and clean energy infrastructure investments, are indispensable for attracting private capital into renewable energy projects. Furthermore, the Climate Bonds Initiative [25] also recognizes the role of green bonds issued by governments in financing sustainable energy projects.

Environmental factors such as air pollution and carbon taxes have also been examined to promote renewable energy consumption, but the empirical results show considerable heterogeneity. Hao and Shao [26] found that countries vulnerable to climate change tend to use more renewable energy, while the impact of carbon taxes is unclear and inconsistent across samples. CO_2 emissions have long been identified as a major driver of energy transition policies. Grossman and Helpman [27] argued through the environmental Kuznets curve hypothesis that emissions increase in the early stages of economic growth, but after income reaches a certain threshold, concerns about environmental quality lead to reduced emissions. Recent studies, such as Cheikh et al. [28] further confirm the existence of this relationship while highlighting that the nonlinearity differs significantly across regions. Using a Panel Smooth Transition Regression model, the authors show that in the MENA region, renewable energy development is nonlinearly affected by CO_2 emissions and is only truly boosted when a country reaches a certain threshold of income and emissions. This result suggests that countries in the early stages of rapid industrialization and urbanization must adopt stronger supportive policies to promote the transition to a sustainable energy model.

Energy use is a key aspect to be analyzed in the energy transition. Studies such as Naeimi, et al. [29] show that countries with high energy efficiency tend to have an easier time transitioning to renewable energy, as they can save costs and invest more in green technologies. Conversely, the pressure on transition costs is significantly higher in countries where energy consumption is still primarily based on fossil sources. This relationship is also supported by research by Al-Mulali, et al. [30] which shows that rapid urbanization increases energy demand and complicates the transition to sustainable energy sources.

One of the emerging factors that has received increasing attention in recent years is geopolitical risk (GPR). According to Caldara and Iacoviello [3], geopolitical risk (GPR) refers to threats and escalations related to war, terrorism, and international tensions, and is measured by the GPR Index based on the frequency of geopolitical terms in global news. It serves as a reliable indicator of global instability and uncertainty. GPR has impacted the economy and the country as a whole Zhang et al. [31]. Le et al. [32] demonstrated that geopolitical risk has both direct and indirect impacts on the stock market. In detail, GPR exacerbates stock bubbles in the Vietnamese stock market through mediating factors such as natural gas prices and long-term interest rates. Previous research has highlighted the impact of GPR on renewable energy. Studies such as Sweidan [33], using panel cointegration techniques, show that geopolitical conflicts can promote the reduction of fossil fuel dependence and the shift to alternative energy sources when examining data from a group of 10 net oil-importing economies. This mechanism is often explained through the substitution effect: disruptions in fossil fuel supplies due to geopolitical conflicts increase oil prices, encouraging investment in renewable energy to reduce supply risks and enhance energy security. At the same time, major crises such as the Russia-Ukraine war, conflicts in the Middle East, and US-China tensions have disrupted the global fossil fuel supply chain, prompting major economies such as Europe and China to promote energy self-sufficiency strategies and invest in renewable energy [33, 34].

However, the empirical results on the impact of geopolitical risks on renewable energy remain controversial. Some studies, such as Dong et al. [35], apply the cross-sectional ARDL model of Chudik and Pesaran [36] to analyze the relationship between renewable energy investment and geopolitical instability in the BRICS group. The empirical results show that geopolitical volatility is beneficial in promoting clean technology. Similar results are also observed for clean energy stocks [37, 38]. This finding is also confirmed in the case of 37 European countries in Hille's study. The author argues that geopolitical crises will accelerate the transition to clean energy solutions in Europe. In particular, controlling for the geopolitical context in oil-exporting countries is important to assess whether it promotes renewable energy development. Hille [39] proposed considering the geopolitical context in energy-supplying countries and how it may affect the renewable energy sector in fossil fuel-importing countries. From there, the author also examined the moderating role of electricity prices. The empirical results confirm that geopolitical conflicts will strongly encourage European countries to develop the clean energy sector.

On the contrary, some evidence suggests a negative impact. Zhao, et al. [40], using a panel of 20 OECD countries, estimated the impact of geopolitical risk (GPR) using the general method of moments (GMM) system method, indicating that geopolitical tensions hinder the development of renewable energy by increasing financial instability and the investment climate. This is because geopolitical conflicts lead to a decline in the use of renewable energy sources. Environmental damage caused by geopolitical instability has also been confirmed by Wang et al. [41] for the G20 group of countries. The authors studied the relationship between international conflict and environmental sustainability using quantile regression, employing the method of moments, which is capable of handling nonlinear models and complex data structures. The results show that geopolitics negatively impacts sustainability by undermining international cooperation and environmental protection efforts. Pata [42] in the G7 also confirmed the negative effects of the geopolitical environment. However, economic policy uncertainty has a more pronounced impact on clean energy investment [19].

This negative impact is particularly pronounced in middle-income countries or countries with weak financial infrastructure, as Chu et al. [43] and Cheikh and Zaied [44] confirmed. In addition, economic policy uncertainty (EPU), measured by Baker et al. [19], is also found to exacerbate the negative impact of geopolitical risk on clean energy investment.

Heterogeneity in impacts across countries and periods has also been noted. Studies by Su et al. [45] and Cai and Wu [46] have documented a time-varying relationship between renewable energy (RE) deployment and geopolitical crises. They found both positive and negative causal relationships across different periods. For example, rolling window regression techniques show a negative relationship between January–April 2006 and April–September 2009. However, the RE sector was positively affected during periods with high geopolitical risk (GPR), such as the 9/11 terrorist attacks and the 2003 invasion of Iraq.

Furthermore, recent empirical studies have also confirmed that the impact of geopolitical risks on energy transition is heterogeneous over time. Shittu et al. [47] found that the negative impact of geopolitical risks on the Energy Transition Index is more pronounced in countries with low levels of preparedness. In contrast, the positive impact of promoting innovation and enhancing internal capabilities is more substantial in countries with long-term investments in technological development and environmental policies.

This difference is further highlighted by Husain et al. [48] who used the cross-quantilogram technique of Han et al. [49] showing the asymmetric impact of geopolitical shocks on different market states. Chu et al. [43], using quantile regression with non-additive fixed effects following [50] in 30 high- and middle-income economies, showed that renewable energy (RE) is positively affected by geopolitical risks in high-income countries, which helps to reduce environmental degradation. However, in middle-income countries, renewable energy consumption is negatively affected, which hinders the transition to ecologically sustainable development. This is also verified by Ben Cheikh and Ben Zaied [34], who found that in developed economies, geopolitical risks often drive the transition to increase energy security and reduce dependence on imported fossil fuels. Meanwhile, in developing and middle-income countries, financial, technological, and institutional constraints make geopolitical risks a drag on green investment.

In addition, many studies have pointed out the mediating role of factors such as oil prices, energy security needs, and technological innovation capacity in moderating the impact of GPR on energy transition. Sadorsky [51] showed that fluctuations in oil prices are one of the main channels triggering the shift to renewable energy in South American and G7 economies. At the same time, International Energy Agency (IEA) [52] and International Renewable Energy Agency (IRENA) [53] pointed out that regional energy crises, particularly the 2022 European gas crisis, have prompted European countries to adjust their strategies to increase the share of renewable energy.

In addition, macro-financial factors such as exchange rates and financial development capacity are also identified as important mediating variables. Omri et al. [54] and Cheikh et al. [55] emphasize that fluctuations in exchange rates can increase the cost of importing renewable energy technologies, indirectly slowing the transition in volatile geopolitical contexts. In addition, recent studies such as Zhang [56] and Purwanto et al. [57] in the context of Industry 5.0 show that green technology innovation and advances in innovative energy solutions (smart grids, storage technologies) are gradually reducing the dependence of the energy transition on uncertain macroeconomic factors such as geopolitical risks. These technological breakthroughs make renewable energy cheaper and more stable, and improve the resilience of national energy systems to external shocks.

In summary, the impact of changes in the geopolitical landscape on renewable energy transitions remains controversial, and there is no clear consensus. This impact exhibits significant heterogeneity across countries and varies over time. Countries with developed economies, strong environmental policies, and stable financial systems tend to leverage geopolitical shocks better to accelerate green transitions. Meanwhile, emerging economies face more challenges regarding increased global risks. Therefore, institutional capacity building, green finance development, and technological innovation will be key factors in helping countries adapt to the uncertain geopolitical landscape and promote sustainable energy transitions. This is also why international organizations such as the Climate Bonds Initiative [25] and Green Finance Platforms promote green finance initiatives specifically for countries vulnerable to geopolitical risks.

Finally, it is important to emphasize that energy transitions in the context of geopolitical uncertainty are not only a challenge but also an opportunity to reshape global energy systems in a safer, greener, and more sustainable way. Studies such as those by the International Energy Agency (IEA) [52], ADB [23] and World Bank [58] all agree that if managed well, current geopolitical shocks can become powerful catalysts for the transition to a cleaner, more equitable, and more resilient energy future for the world.

These findings suggest several important policy implications. To minimize the negative impacts of geopolitical risks and maximize the opportunities for sustainable energy transitions, countries must develop energy diversification strategies, enhance green technology innovation, promote green finance, and establish effective regulatory and environmental protection institutions. Promoting international cooperation, primarily through climate finance and technology transfer initiatives, is also urgent to ensure that the energy transition does not exacerbate global inequality. In this study, we focus on the impact of geopolitical risks on renewable energy use in the Asia-Pacific region.

3. Data, Methodology, and Research Model

3.1. Data and Variables in the Model

The study uses panel data from 12 Asia-Pacific countries from 2000 to 2021 to assess the impact of geopolitical risks on renewable energy use. The selected countries represent emerging nations in the region, with clear and complete data sources, ensuring a robust research sample. These countries have contributed significantly to the region's development.

3.1.1. Dependent Variable

The dependent variable is the ratio of renewable energy use to total energy, taken from the World Bank website.

3.1.2. Independent Variables

The independent variables include: GPR Index. This study uses the GPR index that Caldara and Iacoviello [3] developed, based on text data from dozens of major international newspapers. The GPR index measures "the risk associated with war, terrorist acts, and tensions between countries that affect the normal and peaceful course of international relations" [3]. This index measures the frequency of occurrence of keywords such as "war," "military tensions," "terrorist threat," etc., in newspaper articles. Unlike dummy variables or the number of conflict events, this GPR index reflects market perceptions (perceived risk). This factor is increasingly appreciated because it directly affects business behavior, regardless of whether the risk occurs [59]. This study used a 12-month GPR to obtain the annual GPR.

Geopolitical risks related to war, terrorism, and tensions between countries threaten foreign direct investment by increasing the risks and costs of doing business and transacting globally [60]. As geopolitical risks increase, developed countries may view this as a driver for transition to enhance their energy security and reduce their dependence on fossil fuels from other countries. However, increasing geopolitical risks in developing countries may diminish the financial resources available for renewable energy development.

The research hypothesis put forward in this study is that geopolitical risks have a negative impact on renewable energy use.

3.2. Control Variables

The author has included several control variables in the model in addition to the GPR variable. Macroeconomic factors believed to influence the use of renewable energy include GDP growth, FDI, TRADE, INF, GCE, and DC.

Economic growth, represented by the GDP growth variable, is one of the driving forces behind the renewable energy transition [4, 5]. However, according to the threshold effect, when national income exceeds a certain threshold, energy demand increases rapidly to the point that renewable energy cannot meet it, leading to a decrease in the share of renewable energy in the total energy mix [6, 7].

Foreign direct investment (FDI) is also believed to impact the use of renewable energy. FDI helps recipient countries access new technologies and financial resources to promote renewable energy [13]. However, FDI in developing countries can promote the use of fossil fuels, causing environmental pollution [14].

International trade is also thought to influence a country's use of renewable energy. Trade integration helps countries gain faster access to renewable energy technologies, thereby promoting the use of this energy source [15, 16]. However, increased trade may also require a larger amount of energy consumption, which promotes the use of fossil fuels.

Inflation is also a macro factor affecting the energy transition. High inflation increases investment costs for renewable energy projects, limits investment flows, and negatively impacts the use of renewable energy [18, 19].

Government spending is important for supporting renewable energy development alongside private investment. A country interested in investing in and developing renewable energy will create a strong driving force, promoting renewable energy consumption [23, 24].

As measured by the domestic credit index to the private sector, financial development is also an important driver of renewable energy investment. Levine [10] and Islam et al. [11] both argue that a developed financial system will reduce the cost of capital, improve access to long-term capital, and promote green energy investment.

CO_2 emissions have also been identified as an important driver of the energy transition. Significant CO_2 emissions lead to environmental pollution. Countries vulnerable to climate change tend to use more renewable energy [26].

Countries with high energy efficiency are often more likely to transition to renewable energy, as they can save costs and invest more in green technologies. In contrast, in countries where energy consumption is still primarily based on fossil sources, the pressure of transition costs will be significantly higher [29].

Table 1.
Description of variables used in the model.

Variable	Abbriviation	Description	Sources
Renewable energy consumption rate	RE	Renewable energy share of total energy (%)	World Bank
Foreign direct investment growth	FDI	FDI growth (growth rate year after year)	World Bank
Gross domestic product growth	GDP	The growth of total value of all final goods and services produced by a country or region in a given period of time	World Bank
Trade	TRADE	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.	World Bank
Geopolotical risk index	GPR	The average 12 months GPRI in a year	Caldara and Iacoviello [3]
Inflation	INF	Inflation, as measured by the consumer price index, reflects the annual percentage change in the cost to the average consumer of purchasing a basket of goods and services that may be fixed or vary over specific time periods, such as annually.	World Bank
Carbon dioxide (CO2) emissions excluding LULUCF per capita (t CO2e/capita)	CO2EPC	Total annual carbon dioxide (CO2) emissions, one of the six Kyoto greenhouse gases (GHGs), from the agriculture, energy, waste, and industry sectors, excluding LULUCF, normalized to carbon dioxide equivalent values divided by the population of the economy.	World Bank
General government final consumption expenditure growth	GCE	Growth in general government final consumption expenditure (formerly general government spending) includes all current government spending on goods and services (including employee wages).	World Bank
Domestic credit to private sector by banks (% of GDP)	DC	Domestic credit to the private sector by banks refers to the financial resources provided to the private sector.	World Bank
Energy use (kg of oil equivalent per capita)	Energy PC	Energy use refers to the use of primary energy before transformation into other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.	World Bank

3.3. Research Model and Hypothesis

To quantitatively assess the impact of GPR on renewable energy consumption in Asia-Pacific countries, the author, based on the above theoretical basis and previous studies by Chen et al. [61] and Rasoulinezhad and Taghizadeh-Hesary [62] builds a research model:

$$RE = \beta + \beta_1 \text{ x FDI} + \beta_2 \text{ x TRADE} + \beta_3 \text{ x INF} + \beta_4 \text{ x CO2EPC} + \beta_5 \text{ x GDPgrowth} + \beta_6 \text{ x GCE} + \beta_7 \text{ x DC} + \beta_8 \text{ x EnergyPC} + \beta_9 \text{ x GPR} + \epsilon$$

a_1: Constant
$\beta_1, \ldots, \beta_9$: regression coefficient
e: residual

Based on the presented theory, the study builds a research hypothesis to test the relationship between GPR and the rate of renewable energy consumption in countries in the Asia-Pacific region.

Research hypothesis H1: GPR of a country has a negative impact on the rate of renewable energy use of that country.

3.4. Methodology

The collected data are panel data from 12 countries in the Asia-Pacific region, covering the period from 2000 to 2021. The author employs the panel data processing method. The data is entered and processed using Stata software. Before conducting regression analysis, the author performs descriptive statistics for each variable in the model to understand the characteristics and properties of the data and analyzes the correlation to determine the relationships between the variables in the research model. A high correlation between variables can affect the regression results of the model. The fixed effects model (FEM), random effects model (REM), and GLS model are used to assess the impact of GPR on the renewable energy consumption rate of a country.

The ordinary least squares regression method is the basic method to estimate the relationship between dependent and independent variables. The fixed effects model helps to control for unobservable factors that may vary across countries but do not vary over time. The random effects model assumes that the unobservable factors are random and uncorrelated with the independent variable. The Hausman test selects the more appropriate model from the models mentioned above. Model error tests are performed to assess error variance and autocorrelation and to correct model errors using appropriate methods.

3.5. Research Results and Discussion

The correlations between variables in the model are shown in Table 2.

Table 2.
Correlations between variables in the model

	RE	FDI	TRADE	INF	CO2EPC	GDP growth	GCE	DC	GPR
RE	1.0000								
FDI	0.0674	1.0000							
TRADE	0.0063	-0.0680	1.0000						
INF	0.3913	-0.0205	0.1212	1.0000					
CO2EPC	-0.7367	-0.0174	-0.2093	-0.3028	1.0000				
GDP growth	0.2449	0.0446	0.1662	0.1966	-0.2013	1.0000			
GCE	-0.6690	-0.0014	-0.4886	-0.3585	0.5805	-0.1653	1.0000		
DC	-0.5849	0.0294	0.1920	-0.3881	0.6639	-0.0006	0.5340	1.0000	
GPR	-0.3355	0.0157	-0.2821	-0.1761	0.2912	0.1121	0.6004	0.4466	1.0000

The independent variable pairs in the model all have low correlation coefficients, with absolute values less than 0.8, thus limiting the phenomenon of multicollinearity in the model.

Pooled OLS, FEM and REM models are regressed and tested respectively to select the appropriate model. The results are shown in Table 3.

Table 3.
Pooled OLS, FEM and REM regression results.

Variables	Pooled OLS	FEM	REM
FDI	0.00058	-0.01749	-0.17708
TRADE	-0.19390 (***)	-0.07655 (***)	-0.09227 (***)
INF	0.74751 (***)	0.11000	0.15091
CO2EPC	-1.84330 (***)	-1.22953 (***)	-1.41210 (***)
GDPgrowth	0.28489 (**)	-0.09342	-0.05181
GCE	-14.12441 (***)	-10.92218 (***)	-11.01519 (***)
DC	0.14025 (***)	0.02602	0.03517 (*)
GPR	-4.91029 (***)	1.76525	1.72794
Level of significance	* 10%; ** 5%; *** 1%		

Model selection tests were used to evaluate and select the appropriate model, and the Hausman test results demonstrated that the FEM (fixed effects model) was the most relevant. However, the heteroscedasticity and autocorrelation test results showed that the FEM model exhibited heteroscedasticity and autocorrelation.

Table 4.
Results of testing for heteroskedasticity and autocorrelation.

Test	P value	Conclusion
Heteroscedasticity	0.0000	Yes
Autocorrelation	0.0000	Yes

To overcome the phenomenon of heteroscedasticity and autocorrelation of the FEM model, the GLS model is used for the results, as shown in Table 5.

Table 5.
GLS model estimation results.

Variables	GLS
FDI	-0.00456
TRADE	-0.09648 (***)
INF	0.09386 (***)
CO2EPC	-1.46638 (***)
GDPgrowth	0.02206
GCE	-9.98776 (***)
DC	0.02885 (***)
GPR	0.97871 (***)

Looking at the GLS regression results, it can be seen that GPR has a positive impact on a country's renewable energy consumption rate at the 1% significance level. Geopolitical risks strongly promote the use of renewable energy. This research result is consistent with the research results of Sweidan [33], Ben Cheikh and Ben Zaied [34], Wang et al. [41] and Chudik and Pesaran [36]. Geopolitical risks disrupt the global fossil fuel supply chain and increase the cost of fossil fuels, thereby encouraging countries to invest in and use renewable energy to reduce supply risks and enhance energy security during a crisis.

In addition, the control variables, INF and DC, positively impact the dependent variable RE at the 1% significance level. Inflation has a positive impact on the use of renewable energy. This result is contrary to the research results of Abdullah et al. [18] and Baker et al. [19]. This can be explained by the fact that increased inflation increases the price of fossil fuels due to increased costs, reducing the consumption of fossil fuels, and increasing the use of renewable energy. The development of the financial system, measured by the domestic credit index for the private sector, has a positive impact on the consumption rate of renewable energy. This result is similar to the research results of Wang et al. [8], Chang, et al. [9], Levine [10] and Islam et al. [11]. A developed financial system reduces the cost of capital, increases access to long-term capital, and promotes renewable energy development. In addition, the GDP growth variable positively impacts RE but is not statistically significant with a large p-value.

The variables TRADE, CO2EPC, and GCE negatively impact the rate of renewable energy consumption at the 1% significance level, where the impact of TRADE is small, and the impact of GCE is the largest. More developed trade will reduce the rate of renewable energy use. This result is contrary to the research findings of Saidi and Hammami [15] but similar to those of Nasreen and Anwar [17]. The impact of trade on the energy transition depends on the import-export structure and the trade-environmental policy of a country. Increasing trade, especially fossil fuel trade, can promote fossil energy consumption instead of fostering renewable energy development. CO2 emissions have a negative impact on the rate of renewable energy consumption. This result contradicts the previous research findings of Hao and Shao [26] and Grossman and Helpman [27], who argued that CO2 emissions are the main driver of energy transition policies. However, in the study by Ben Cheikh and Ben Zaied [63], the authors also argued that there is a threshold effect in the relationship between CO2 emissions and renewable energy. Only when a country reaches a threshold level of CO2 emissions will the rate of renewable energy use improve. GCE is a proxy for government spending, which has a negative impact on the rate of renewable energy use. Although this is contrary to previous research findings by ADB [23] and International Finance Corporation (IFC) [24], it can be explained by the dependence on each country's renewable energy development orientation. Enormous public spending, but not focusing on renewable energy development, can increase fossil fuel use. FDI has a negative impact on the rate of renewable energy use, but it is not statistically significant.

The regression results from the GLS model above show the positive impact of geopolitical risks on the rate of renewable energy use. At the same time, they demonstrate the impact of several other macroeconomic factors, such as trade, inflation, government spending, the level of financial sector development, and CO2 emissions, on the rate of renewable energy use.

4. Conclusion and Policy Implications

This paper examines the impact of geopolitical risks on renewable energy adoption, empirically studying countries in the Asia-Pacific region from 2000 to 2021 using panel data and GLS regression models. The results demonstrate a positive impact of geopolitical risks on the renewable energy transition at the 1% statistical significance level. This research result is similar to previous studies on the impact of geopolitical risks on the renewable energy transition. In the context of increasing geopolitical risks, as they are today, the research results are meaningful in suggesting some renewable energy policies in countries in the Asia-Pacific region. Countries tend to switch to renewable energy to reduce their dependence on imported fossil fuels, a fuel source that is increasing in cost due to supply disruptions caused by geopolitical risks. Governments need to consider policies focusing on renewable energy development to ensure net-zero emissions and energy security. Geopolitical risks can create natural momentum for the transition. However, countries need policies to promote private investment and financial support, such as subsidies, tax incentives, and infrastructure development for renewable energy development.

Although this study contributes to the understanding of the impact of geopolitical risks on renewable energy (RE) use, its scope is limited to the Asia-Pacific region, with restricted data sources. To enhance the robustness of the findings and assumptions, future research efforts can extend the investigation to different contexts and regions and further explore the mechanisms that cause changes in GPR spillovers.

References

[1] IEA, *CO_2 Emissions in 2022*. France: OECD Publishing, 2023.
[2] IEA, *World energy outlook 2023*. France: International Energy Agency, 2023.
[3] D. Caldara and M. Iacoviello, "Measuring geopolitical risk," *American Economic Review,* vol. 112, no. 4, pp. 1194-1225, 2022.
[4] N. Apergis and J. E. Payne, "Renewable energy, output, carbon dioxide emissions, and oil prices: Evidence from South America," *Energy Sources, Part B: Economics, Planning, and Policy,* vol. 10, no. 3, pp. 281-287, 2015.
[5] T. Chang, R. Gupta, R. Inglesi-Lotz, B. Simo-Kengne, D. Smithers, and A. Trembling, "Renewable energy and growth: Evidence from heterogeneous panel of G7 countries using Granger causality," *Renewable and Sustainable Energy Reviews,* vol. 52, pp. 1405-1412, 2015.
[6] A. C. Marques, J. A. Fuinhas, and J. P. Manso, "Motivations driving renewable energy in European countries: A panel data approach," *Energy policy,* vol. 38, no. 11, pp. 6877-6885, 2010.
[7] I. Cadoret and F. Padovano, "The political drivers of renewable energies policies," *Energy Economics,* vol. 56, pp. 261-269, 2016.
[8] Z. Wang, T. L. H. Pham, K. Sun, B. Wang, Q. Bui, and A. Hashemizadeh, "The moderating role of financial development in the renewable energy consumption-CO2 emissions linkage: The case study of Next-11 countries," *Energy,* vol. 254, p. 124386, 2022. https://doi.org/10.1016/j.energy.2022.124386
[9] L. Chang, C. Qian, and A. Dilanchiev, "Nexus between financial development and renewable energy: Empirical evidence from nonlinear autoregression distributed lag," *Renewable Energy,* vol. 193, pp. 475-483, 2022.
[10] R. Levine, "Finance and growth: theory and evidence," *Handbook of Economic Growth,* vol. 1, pp. 865-934, 2005.
[11] F. Islam, M. Shahbaz, A. U. Ahmed, and M. M. Alam, "Financial development and energy consumption nexus in Malaysia: A multivariate time series analysis," *Economic modelling,* vol. 30, pp. 435-441, 2013.
[12] F. Furuoka, "Financial development and energy consumption: Evidence from a heterogeneous panel of Asian countries," *Renewable and Sustainable Energy Reviews,* vol. 52, pp. 430-444, 2015.
[13] J. W. Lee, "The contribution of foreign direct investment to clean energy use, carbon emissions and economic growth," *Energy Policy,* vol. 55, pp. 483-489, 2013.
[14] Y. Liu, Y. Hao, and Y. Gao, "The environmental consequences of domestic and foreign investment: Evidence from China," *Energy Policy,* vol. 108, pp. 271-280, 2017.
[15] K. Saidi and S. Hammami, "The impact of CO2 emissions and economic growth on energy consumption in 58 countries," *Energy Reports,* vol. 1, pp. 62-70, 2015.
[16] R. Bellakhal, S. B. Kheder, and H. Haffoudhi, "Governance and renewable energy investment in MENA countries: How does trade matter?," *Energy Economics,* vol. 84, p. 104541, 2019.
[17] S. Nasreen and S. Anwar, "Causal relationship between trade openness, economic growth and energy consumption: A panel data analysis of Asian countries," *Energy Policy,* vol. 69, pp. 82-91, 2014.
[18] K. Abdullah *et al.*, "Renewable energy technologies for economic development," presented at the E3S Web of Conferences, EDP Sciences, 2020.
[19] S. R. Baker, N. Bloom, and S. J. Davis, "Measuring economic policy uncertainty," *The Quarterly Journal of Economics,* vol. 131, no. 4, pp. 1593-1636, 2016.
[20] P. Sadorsky, "The impact of financial development on energy consumption in emerging economies," *Energy policy,* vol. 38, no. 5, pp. 2528-2535, 2010.
[21] M. Bhattacharya, S. R. Paramati, I. Ozturk, and S. Bhattacharya, "The effect of renewable energy consumption on economic growth: Evidence from top 38 countries," *Applied Energy,* vol. 162, pp. 733-741, 2016.
[22] J. M. Keynes, *The general theory of employment, interest, and money, reprint*. USA: Atlantic Publishers, 2008.
[23] ADB, *Green finance and renewable energy in Southeast Asia*. Manila, Philippines: Asian Development Bank, 2023.
[24] International Finance Corporation (IFC), *Green finance in Vietnam: Market landscape and opportunities*. Vietnam: International Finance Corporation, 2023.
[25] Climate Bonds Initiative, *Green bonds global state of the market*. London, United Kingdom: Climate Bonds Initiative, 2022.
[26] F. Hao and W. Shao, "What really drives the deployment of renewable energy? A global assessment of 118 countries," *Energy Research & Social Science,* vol. 72, p. 101880, 2021.
[27] G. M. Grossman and E. Helpman, *Innovation and growth in the global economy*. USA: MIT Press, 1991.
[28] N. B. Cheikh, Y. B. Zaied, and J. Chevallier, "On the nonlinear relationship between energy use and CO2 emissions within an EKC framework: Evidence from panel smooth transition regression in the MENA region," *Research in International Business and Finance,* vol. 55, p. 101331, 2021.
[29] E. Naeimi, M. H. Askariazad, and K. Khalili-Damghani, "Forecasting the effect of renewable energy consumption on economic welfare: Using artificial neural networks," *International Journal of Management, Accounting & Economics,* vol. 2, no. 1, pp. 65–75, 2015.
[30] U. Al-Mulali, H. G. Fereidouni, J. Y. Lee, and C. N. B. C. Sab, "Exploring the relationship between urbanization, energy consumption, and CO2 emission in MENA countries," *Renewable and Sustainable Energy Reviews,* vol. 23, pp. 107-112, 2013.
[31] Y. Zhang, J. He, M. He, and S. Li, "Geopolitical risk and stock market volatility: A global perspective," *Finance Research Letters,* vol. 53, p. 103620, 2023. https://doi.org/10.1016/j.frl.2022.103620
[32] P. L.-P. Le, D. Thai2-Vu, M. H. Van Duc3-Nguyen, T. M. T.-N. Tran, and T. M. Hoa, "The impact of geopolitical risk on the stock market and stock bubbles in Vietnam: A mediation model," *Journal of Economic and Banking Studies*, vol. 4, no. 2, pp. 50–65, 2024. https://doi.org/10.59276/JEBS.2024.12.2684

[33] O. D. Sweidan, "Is the geopolitical risk an incentive or obstacle to renewable energy deployment? Evidence from a panel analysis," *Renewable Energy*, vol. 178, pp. 377-384, 2021.
[34] N. Ben Cheikh and Y. Ben Zaied, *Does geopolitical uncertainty matter for the diffusion of clean energy?* Advance Online Publication. https://doi.org/10.1016/j.econmod.2024.106161, 2024.
[35] C. Dong, H. Wu, J. Zhou, H. Lin, and L. Chang, "Role of renewable energy investment and geopolitical risk in green finance development: Empirical evidence from BRICS countries," *Renewable Energy,* vol. 207, pp. 234-241, 2023. https://doi.org/10.1016/j.renene.2023.02.123
[36] A. Chudik and M. H. Pesaran, "Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors," *Journal of Econometrics,* vol. 188, no. 2, pp. 393-420, 2015. https://doi.org/10.1016/j.jeconom.2015.02.006
[37] A. Dutta and P. Dutta, "Geopolitical risk and renewable energy asset prices: Implications for sustainable development," *Renewable Energy,* vol. 196, pp. 518-525, 2022. https://doi.org/10.1016/j.renene.2022.07.062
[38] M. Umar, Y. Riaz, and I. Yousaf, "Impact of Russian-Ukraine war on clean energy, conventional energy, and metal markets: Evidence from event study approach," *Resources Policy,* vol. 79, p. 102966, 2022. https://doi.org/10.1016/j.respol.2022.102966
[39] E. Hille, "Europe's energy crisis: are geopolitical risks in source countries of fossil fuels accelerating the transition to renewable energy?," *Energy Economics,* vol. 127, p. 107061, 2023. https://doi.org/10.1016/j.eneco.2023.107061
[40] Z. Zhao, G. Gozgor, M. C. K. Lau, M. K. Mahalik, G. Patel, and R. Khalfaoui, "The impact of geopolitical risks on renewable energy demand in OECD countries," *Energy Economics,* vol. 122, p. 106700, 2023. https://doi.org/10.1016/j.eneco.2023.106700
[41] Q. Wang, X. Wang, and R. Li, "Geopolitical risks and energy transition: The impact of environmental regulation and green innovation," *Humanities and Social Sciences Communications,* vol. 11, no. 1, pp. 1-22, 2024. https://doi.org/10.1057/s41599-024-01392-5
[42] U. K. Pata, "Linking renewable energy, globalization, agriculture, CO2 emissions and ecological footprint in BRIC countries: A sustainability perspective," *Renewable Energy,* vol. 173, pp. 197-208, 2021. https://doi.org/10.1016/j.renene.2021.03.125
[43] L. K. Chu, B. Doğan, S. Ghosh, and M. Shahbaz, "The influence of shadow economy, environmental policies and geopolitical risk on renewable energy: A comparison of high-and middle-income countries," *Journal of Environmental Management,* vol. 342, p. 118122, 2023. https://doi.org/10.1016/j.jenvman.2023.118122
[44] N. B. Cheikh and Y. B. Zaied, "Renewable energy deployment and geopolitical conflicts," *Journal of Environmental Management,* vol. 344, p. 118561, 2023. https://doi.org/10.1016/j.envres.2023.115678
[45] X. Su, U. Razi, S. Zhao, W. Li, X. Gu, and J. Yan, "Geopolitical risk and energy markets in China," *International Review of Financial Analysis,* vol. 103, p. 104187, 2025. https://doi.org/10.1016/j.irfa.2024.104187
[46] Y. Cai and Y. Wu, "Time-varying interactions between geopolitical risks and renewable energy consumption," *International Review of Economics & Finance,* vol. 74, pp. 116-137, 2021. https://doi.org/10.1016/j.iref.2021.06.006
[47] I. Shittu, A. Saqib, and Y. Chen, *Impact of global geopolitical risks on clean energy transition: Evidence from method of moment quantile regression. SSRN*. Rochester, NY: Social Science Research Network, 2024.
[48] S. Husain, K. Sohag, and Y. Wu, "The responsiveness of renewable energy production to geopolitical risks, oil market instability and economic policy uncertainty: Evidence from United States," *Journal of Environmental Management,* vol. 350, p. 119647, 2024. https://doi.org/10.1016/j.jenvman.2023.119647
[49] H. Han, O. Linton, T. Oka, and Y.-J. Whang, "The cross-quantilogram: Measuring quantile dependence and testing directional predictability between time series," *Journal of Econometrics,* vol. 193, no. 1, pp. 251-270, 2016. https://doi.org/10.1016/j.jeconom.2016.03.001
[50] D. Powell, "Quantile regression with nonadditive fixed effects," *Empirical Economics,* vol. 63, no. 5, pp. 2675-2691, 2022. https://doi.org/10.1007/s00181-022-02216-6
[51] P. Sadorsky, "Renewable energy consumption, CO2 emissions and oil prices in the G7 countries," *Energy Economics,* vol. 31, no. 3, pp. 456-462, 2009. https://doi.org/10.1016/j.eneco.2008.12.010
[52] International Energy Agency (IEA), *World energy outlook 2022*. Paris: IEA, 2022.
[53] International Renewable Energy Agency (IRENA), *Renewable energy market analysis: Southeast Asia*. Abu Dhabi: IRENA, 2018.
[54] A. Omri, S. Daly, and D. K. Nguyen, "A robust analysis of the relationship between renewable energy consumption and its main drivers," *Applied Economics,* vol. 47, no. 28, pp. 2913-2923, 2015. https://doi.org/10.1080/00036846.2015.1011312
[55] N. B. Cheikh, Y. B. Zaied, and H. B. Ameur, "Recent developments in exchange rate pass-through: What have we learned from uncertain times?," *Journal of International Money and Finance,* vol. 131, p. 102805, 2023. https://doi.org/10.1016/j.jimonfin.2023.102805
[56] Y.-J. Zhang, "The impact of financial development on carbon emissions: An empirical analysis in China," *Energy Policy,* vol. 39, no. 4, pp. 2197-2203, 2011. https://doi.org/10.1016/j.enpol.2011.02.026
[57] P. Purwanto, R. Rame, and S. Sudarno, "Industry 5.0 and sustainability: An overview of emerging trends and challenges for a green future," *Innovation and Green Development,* vol. 3, no. 4, p. 100173, 2024. https://doi.org/10.1016/j.igd.2024.100173
[58] World Bank, *Vietnam energy transition financing framework.* . Washington, DC: World Bank Group, 2023.
[59] N. Bloom, "The impact of uncertainty shocks," *Econometrica,* vol. 77, no. 3, pp. 623-685, 2009. https://doi.org/10.3982/ECTA6248
[60] S. Singh, G. D. Sharma, M. Radulescu, D. Balsalobre-Lorente, and P. Bansal, "Do natural resources impact economic growth: An investigation of P5+ 1 countries under sustainable management," *Geoscience Frontiers,* vol. 15, no. 3, p. 101595, 2024. https://doi.org/10.1016/j.gsf.2023.101595
[61] L. Chen, T. Zhang, C. Zhang, F. Liu, and Y. Feng, "Does geopolitical risk endanger energy resilience? Empirical evidence from cross-country data," *Polish Journal of Environmental Studies,* vol. 34, no. 3, pp. 2589–2607, 2025. https://doi.org/10.15244/pjoes/188189
[62] E. Rasoulinezhad and F. Taghizadeh-Hesary, "Role of green finance in improving energy efficiency and renewable energy development," *Energy Efficiency,* vol. 15, no. 2, p. 14, 2022. https://doi.org/10.1007/s12053-022-10021-4
[63] N. Ben Cheikh and Y. Ben Zaied, "A new look at carbon dioxide emissions in MENA countries," *Climatic Change,* vol. 166, no. 3, p. 27, 2021. https://doi.org/10.1007/s10584-021-03126-9