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Research article

Effect of geopolitical risk on energy consumption policy: New empirical evidence from BRICS

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ABSTRACT

This study investigates the impact of geopolitical risk (GPR) on energy consumption. For empirical analysis, we utilize the dataset of BRICS nations spanning 25 years from 1998 to 2022. We employ three econometric models, namely fully modified ordinary least squares (FMOLS), dynamic ordinary least squares (DOLS), and autoregressive distributed lag (ARDL), to analyze the relationships between GPR and energy consumption. Our empirical findings reveal several significant insights. Firstly, we observe a substantial negative influence of GPR on both fossil fuel energy consumption (FEC) and total energy consumption (TEC). This suggests that higher levels of GPR are associated with reduced utilization of fossil fuels and overall energy consumption within the BRICS countries. Conversely, we identify a significant positive effect of GPR on renewable energy consumption (REC). This implies that, as GPR rises, there is a corresponding increase in the adoption and usage of renewable energy sources. Furthermore, our analysis uncovers the presence of asymmetric effects pertaining to other key determinants of energy consumption, including FDI inflow, economic growth, banking sector development, and inflation rate. This study offers fresh empirical evidence on the intricate interplay between GPR and energy consumption in BRICS nations, shedding light on the significant impacts of GPR and the nuanced effects of various economic factors. These findings have important implications for policymakers and stakeholders seeking to navigate energy policy decisions in a geopolitically dynamic world.

1. Introduction

In an increasingly interconnected world, energy plays a pivotal role in powering economies and shaping global politics [1]. The availability, accessibility, and affordability of energy resources are not only essential for the prosperity of nations but are also intricately linked with the geopolitical landscape. The relationship between energy policy and geopolitics is a complex and dynamic one, with nations constantly maneuvering to secure their energy interests while navigating the uncertainties and risks inherent in the global

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energy landscape. In view this, the current research aims to shed light on the intricate relationship between geopolitical risk and energy policy within the BRICS nations. Geopolitical risk (GPR) refers to the uncertainties and tensions arising from political, economic, and security factors that can impact a country's energy policy decisions [2]. These risks can manifest in various forms, such as trade disputes, regional conflicts, sanctions, and political instability. To better comprehend this multifaceted relationship, we will explore new empirical evidence derived from the BRICS (Brazil, Russia, India, China, South Africa) countries, providing insights into the ways geopolitical risk influences their energy policies.

The interplay between geopolitics and energy policy is a dynamic and critical facet of contemporary global affairs. Energy, often referred to as the lifeblood of modern economies, plays a pivotal role in shaping the political, economic, and social landscape of nations and the world at large [3]. Geopolitical risks, such as conflicts, trade disputes, and diplomatic tensions, have a profound impact on energy policy decisions, as they can disrupt the stability of energy supplies, affect energy prices, and challenge the energy security of countries [4]. Energy resources, including fossil fuels, and renewables, have long been recognized as strategic assets that underpin a nation's economic prosperity and security [5]. An access to reliable and affordable energy sources is essential for sustaining industrialization, supporting technological advancements, and improving the quality of life for citizens. Therefore, the formulation and execution of energy policies are crucial for governments worldwide. GPR encompass a wide range of factors, including territorial disputes, military conflicts, sanctions, trade negotiations, and alliances. These risks can have direct and indirect consequences on the energy sector. For instance, military conflicts in major oil-producing regions can disrupt the production and transportation of oil, leading to price spikes and supply disruptions [6]. Trade disputes and sanctions can impact energy trade and investment, affecting energy security and economic stability.

Geopolitical risk is an increasingly influential factor that affects global energy policy decisions, with potential implications for energy security, sustainability, and economic stability [7]. Understanding the complex interplay between GPR and energy policy is crucial for policymakers, energy industry stakeholders, and researchers. This study aims to investigate the effect of geopolitical risk on energy policy and its multifaceted impacts, with the goal of providing valuable insights into the development of more resilient and effective energy strategies. The motivation behind this study lies in the pressing need to comprehensively examine the relationship between geopolitical risk and energy policy. In an interconnected global energy landscape, geopolitical events, such as conflicts, trade disputes, and sanctions, can disrupt energy supply chains and impact the reliability of energy sources. These disruptions have the potential to jeopardize a nation's energy security, leading to economic vulnerabilities and potential conflicts. In summary, this study's motivation stems from the recognition that geopolitical risk is a dynamic and potent force shaping the global energy landscape. Analyzing its impact on energy policy is essential for addressing energy security, sustainability, and economic stability concerns in an ever-changing world.

The rationale of this study stems from the recognition of the dynamic and influential role played by GPR in shaping energy consumption within the BRICS nations. In an increasingly interconnected world, energy policies are crucial for the prosperity and security of nations, and the interplay between geopolitics and energy policy is complex. Geopolitical risks, such as conflicts, trade disputes, and political instability, can significantly impact energy policy decisions by disrupting energy supplies, affecting prices, and challenging energy security.

This study aims to find out the impact of GPR on energy consumption. To achieve the aim, we conducted the empirical analysis on 25 years (1998-202) of data of BRICS nations and employ FMOLS, DOLS, and ARDL models for regression analysis. The findings reveal the significant negative effect of GPR on fossil fuel energy consumption while a significant positive effect on renewable energy consumption. In addition, we find the significant negative effect of GPR on overall energy consumption. Geopolitical instability can contribute to volatile oil and gas prices, making long-term planning and investment in fossil fuel-dependent industries more challenging. This uncertainty can deter businesses and consumers from relying heavily on fossil fuels. In contrast, geopolitical instability and concerns about energy security can motivate governments and businesses to invest in domestic renewable energy sources. This promotes the development and consumption of renewable energy as a more stable and secure alternative. The empirical analysis documents the dynamic impact of control variables including FDI inflow, economic growth, banking sector development, and inflation rate on energy consumption of BRICS economies.

The study contributes to the theoretical understanding of how geopolitical risk factors influence energy policy decisions in the context of BRICS nations. It may shed light on the complexities and nuances of energy policymaking in geopolitically diverse regions. The research develops frameworks for assessing and measuring the impact of GPR on energy policy, potentially providing a theoretical basis for future studies in this area. Empirically, the study provides fresh empirical evidence about how BRICS countries formulate their energy policies in response to geopolitical risk. This empirical data enriches the understanding of real-world policy decisions. Practically, the study's insights encourage greater cooperation and collaboration among BRICS countries in addressing common energy-related challenges arising from geopolitical risks. This could lead to more coordinated approaches to global energy issues. Businesses and investors operating in the energy sector can gain valuable insights into potential risks and opportunities in BRICS markets, allowing them to develop more effective risk mitigation strategies. Policymakers within BRICS nations can use the study's findings to make informed decisions about energy policy strategies that account for geopolitical risk factors. This can help enhance energy security and stability within these countries.

This research is organized into distinct sections, each dedicated to a specific facet of the study. After this introductory section, the subsequent part conducts a thorough literature review, encompassing existing research on innovation, geopolitical risk, and their interplay. Moving forward, the third section elucidates the empirical study's methodology, elucidating data sources, variables, and the statistical methods applied to assess the connection between geopolitical risk and innovation. The ensuing section divulges the empirical findings derived from our study. Subsequently, the fifth section deliberates upon and interprets the study's outcomes. In conclusion, the final section encapsulates our main findings.

2. Review of literature

The intricate dynamics between changes in geopolitical risks and fluctuations in energy consumption are pivotal to understanding how these interactions influence policy decisions. Geopolitical risks, ranging from trade disputes to political instability, can impact energy consumption by introducing uncertainties that affect the stability of energy supplies and contribute to volatility in energy prices. In times of heightened geopolitical tension, nations may experience a decrease in energy consumption, driven by concerns over supply disruptions, economic uncertainties, and a shift towards more sustainable and secure energy sources. Conversely, an increase in geopolitical risks may lead to a surge in energy consumption as governments and businesses seek to ensure energy security through diversified sources. These changes in energy consumption, in turn, shape policy decisions. Policy responses may involve a reevaluation of the energy mix, with a heightened focus on renewable sources to mitigate reliance on geopolitically sensitive fossil fuels. Additionally, policies may be formulated to enhance domestic energy production and storage capabilities as a strategy to navigate geopolitical uncertainties. Therefore, understanding the intricate connections between geopolitical risks, energy consumption patterns, and subsequent policy adjustments is vital for crafting effective and resilient energy strategies in the face of global uncertainties.

In support of above discussion, the link between geopolitical risk (GPR) and energy consumption can be comprehended by reviewing the previous literature. For instance, Rasoulinezhad et al. [8] aimed to explore the empirical linkages between GPR and energy transition in Russia. They employed the ARDL model for regression analysis and found the positive effect of GPR on energy transition from fossil fuel energy to renewable energy consumption, demonstrating the positive effect of GPR on REC while a negative effect on fossil fuel energy consumption (FEC). Zhao et al. [9] examined the asymmetric effect of GPR on energy consumption and CO2 emissions specifically in the case of BRICS economies. The findings of their study disclose the negative effect of GPR on overall energy consumption. In addition, they also observed the negative impact of GPR on CO2 emissions. This negative effect of GPR on energy consumption and CO2 emissions varies across the different regions. Alsagr and Hemmen [10] assessed the impact of GPR and financial development on renewable energy consumption (REC) in emerging markets over the period 1996 to 2015 and found that both GPR and financial development exert a positive effect on REC, demonstrating the sustainable role of both variables in underlying economies. Cai and Wu [4] investigated the dynamic interaction between GPR and REC. Specifically, their analysis discloses the positive effect of GPR on REC. An increased GPR leads to augmenting the consumption of renewable energy.

Prolonging the discussion, Sweidan [11] investigated the relationship between GPR and renewable energy deployment in the US (United States) while hypothesizing whether GPR leads to a cleaner environment or not. The empirical analysis of the study supports the hypothesis of the study as GPR leads to enhancing the REC while reducing the dependency upon FEC. Recently, Zhao et al. [7] examined the impact of GPR on REC in 20 OECD (Organization for Economic Co-operation and Development) countries over the period 1970 to 2019 and found the negative impact of GPR on demand for renewable energy which further threatens the environmental sustainability. In addition, the GDP growth rate and economic globalization lead to boosting the demand for renewable energy. Khan et al. [12] estimated the linkages between GPR, primary energy consumption, militarization, economic uncertainty, and greenhouse gas (GHG) emissions in the case of BRICS. The results of their study infer that both GPR and militarization lead to the deterioration of the environment as both reduce the consumption of renewable energy. However, economic growth protects the environment through the function of boosting the consumption of cleaner energy. Owjimehr et al. [13] intend to find out the impact of GPR on the energy efficiency of 18 European countries over the period 1991 to 2020. They found that GPR leads to accelerating energy efficiency in these economies. They conjectured that a high GPR enhances the investment in energy security and makes the countries cautious regarding future energy consumption. Both factors enhance energy efficiency.

Similarly, Ha [14] suggested that GPR is negatively associated with REC while it is positively related to volatility in renewable energy. High GPR leads to enhanced the volatility in consumption of renewable energy. Sarker et al. [15] explored the empirical relationship between GPR, climate policy uncertainty, crude oil prices, and clean energy prices in the case of the USA. The empirical analysis suggests that an increased climate uncertainty leads to enhancing the prices of cleaner energy. Similarly, they also find the asymmetric effect of GPR on clean energy prices. Jin et al. [16] investigated the spillover effect of GPR and climate risk on energy markets. The findings of their study confirm the connection between climate risk, GPR, and energy market response. Specifically, they disclose the effect of GPR arising from the Russia conflict on energy markets in 2014 and 2022. Despite abundant literature exploring the linkages between GPR and energy consumption, the findings of the literature are still inconclusive, motivating the arrangement of more empirical studies. In addition, no study discloses the explicit impact of GPR on FEC, REC, and total energy consumption in single settings of research. This literature gap can be fulfilled by testing the following hypothesis.

H1. Geopolitical risk has a significant negative effect on fossil fuel energy consumption.

H2. Geopolitical risk has a significant positive effect on renewable energy consumption.

Foreign direct investment (FDI) significantly influences economic growth and its impact on renewable energy consumption varies. Developed economies often prefer to invest in developing and underdeveloped economies due to potentially relaxed ecological sustainability regulations, enabling investors to use non-renewable energy sources. This creates an inverse relationship between FDI and renewable energy utilization [17]. Similarly, Yilanci et al. [18] found an inverse connection between FDI and clean energies. However, some developed economies adopt green and contemporary technologies to mitigate pollution emissions, which attracts FDI towards renewable energy sources, establishing a positive link [19]. Furthermore, Mohsin et al. [20] argue that mature economies have a distinct perspective on polluted and clean energy utilization, positively impacting clean energy usage. Another research by Qamruzzaman [21] suggests that FDI initially reduces clean energy usage but promotes it in the long term.

The financial sector's development has a multifaceted impact on energy usage, which can be understood through various effects:

the stock market effect, consumer effect, income effect, and wealth effect. Financial development, as observed by Sadorsky [22] and Saud et al. [23], stimulates economic growth and subsequently leads to increased energy demand. Further studies by Sadorsky [24] and Khan et al. [25] corroborate this relationship, revealing a significant positive correlation between financial development and energy demand. However, Islam et al. [26] propose an alternative perspective, suggesting that financial development can enhance energy efficiency, thereby reducing energy demand. In a similar vein, He et al. [27] emphasize the constructive impact of higher energy prices on environmental sustainability in China. This is particularly relevant because stable energy prices and sustained economic growth can help mitigate inflationary pressures, contributing to overall environmental benefits.

The study likely draws on several theories to explain how GPR influences energy consumption. One relevant theoretical perspective is rooted in international relations theory, specifically the notion that geopolitical tensions and conflicts can disrupt the stability of energy supplies. This theory posits that events such as trade disputes, regional conflicts, and political instability can lead to uncertainties in global energy markets, impacting the availability and affordability of energy resources. Another theoretical lens that may be considered is the theory of energy security. This perspective emphasizes the importance of ensuring a stable and reliable energy supply to meet a nation's needs. Geopolitical risks, such as territorial disputes or military conflicts in key energy-producing regions, can pose threats to energy security by potentially disrupting the production and transportation of oil and gas, leading to price spikes and supply disruptions.

Moreover, economic theories related to risk and uncertainty could be integrated into the analysis. These theories suggest that higher geopolitical risks may create uncertainties in economic environments, influencing consumer and investor behavior. In the context of the study, businesses and consumers might be deterred from relying heavily on fossil fuels due to the volatile geopolitical landscape, thereby affecting overall energy consumption patterns. Additionally, the study may consider theories related to the geopolitical aspects of renewable energy adoption. For instance, the theory of energy transition posits that geopolitical risks can serve as catalysts for a shift towards renewable energy sources, driven by concerns about energy security and the environmental impacts of fossil fuel use. This theory suggests that nations may increase their adoption of renewable energy as a response to geopolitical risks, contributing to a more sustainable and secure energy future.

In summary, the study likely incorporates elements from international relations theory, energy security theory, economic theories of risk and uncertainty, and theories related to energy transition to theorize and explain how geopolitical risk influences energy consumption. The combination of these theoretical perspectives provides a comprehensive framework for understanding the complex interplay between geopolitical dynamics and energy strategies in the studied context.

3. Data and methods

3.1. Data and sample

The empirical analysis was conducted on 25 years of data over the period 1998–2022 of BRICS economies. We select the BRICS (Brazil, Russia, India, China, and South Africa) because these economies are significant players in the global energy landscape. These nations are not only among the world's largest energy consumers but also face unique geopolitical challenges that can influence their energy consumption policies [9]. Therefore, focusing on BRICS countries provides a meaningful context for studying the impact of geopolitical risk on energy consumption. In addition, BRICS nations play a vital role in shaping global energy markets [28]. Therefore, studying the effects of GPR on their energy consumption policies can provide insights into broader global energy dynamics and their implications for energy security and sustainability. Similarly, the motivation for selecting the specific span (1998–2022) includes because the data for the selected time span (1998–2022) is relatively consistent and available for BRICS countries. This consistency is crucial for conducting a comprehensive and reliable empirical analysis of the relationship between GPR and energy consumption.

The selected time span of 1998–2022 encompasses a period marked by significant geopolitical events, including conflicts, sanctions, and trade disputes that have the potential to disrupt energy markets. Therefore, analyzing the data over this period allows us to capture the influence of these geopolitical factors on energy consumption policies. Moreover, the data spanning over two decades enables a longitudinal analysis of how GPR has evolved and impacted energy consumption policies in BRICS countries. This long-term perspective can reveal trends and patterns that may not be evident in shorter timeframes. The data of GPR was collected from an online site[1] on which the data were scored by Caldara and Iacoviello [2]. Similarly, the data of other variables were obtained from WDI (World Development Indicators), The World Bank.

3.2. Variables of study

In this study, energy consumption (ECP) is a dependent variable which was measured by three proxy variables including fossil fuel energy consumption (FEC), renewable energy consumption (REC), and total energy consumption (TEC). The FEC refers to the use of energy derived from fossil fuels, which are non-renewable resources. Fossil fuels include coal, oil, and natural gas. This type of energy consumption involves burning these fuels to generate electricity, heat, or power for various applications, such as transportation, electricity generation, and industrial processes. Similarly, REC refers to the use of energy derived from naturally replenishing sources that are considered environmentally sustainable. These sources include sunlight (solar energy), wind (wind energy), water flow

[1] https://www.matteoiacoviello.com/gpr.htm.

(hydroelectric energy), geothermal heat, and biomass. Unlike fossil fuels, renewable energy sources are not depleted when used and have a lower environmental impact in terms of greenhouse gas emissions. We calculate the FEC and REC as a percentage of total energy consumed during a year. Total energy consumption represents the overall amount of energy used within a specific region, sector, or timeframe. It encompasses all forms of energy, including fossil fuels, renewable energy, nuclear energy, and other sources. In this study, TEC was measured total energy consumed in kg of oil equivalent per capita. Such measurement of ECP was observed in recent studies [4,7,9].

We regressed the ECP by geopolitical risk (GPR) which is a main explanatory variable in this study. GPR was assessed by an index developed by Caldara and Iacoviello [2]. GPR refers to the potential hazards and uncertainties arising from the interactions and conflicts between countries or regions on the global stage. These risks can result from various factors, including territorial disputes, trade tensions, military conflicts, economic sanctions, political instability, and changes in government policies. GPR can significantly impact international relations, trade, investments, and the stability of global markets, making it a crucial consideration for businesses, governments, and individuals when making strategic decisions or assessing potential threats to their interests. The studies of Cai and Wu [4], and Magazzino [29] investigated the impact of GPR on energy consumption. In addition to GPR, the analysis includes some control variables inclduing FDI inflow, economic growth, bank development, and inflation rate. These are the well known variables and have utilized by some recent studies as potential determinants of energy consumption [30–32]. Table 1 shows the detail of variables.

3.3. Equations and methodology discussion

The relationship between the variables can be expressed in the shape of following equations

$$ECP = f(GPR, FDI, ECG, BSD, IFR)$$

$$FEC_{it} = \beta_{\circ} + \alpha_1 GPR_{it} + \beta_2 FDI_{it} + \beta_2 ECG_{it} + \beta_3 BSD_{it} + \beta_4 IFR_{it} + \varepsilon_{it} \quad (1)$$

$$REC_{it} = \beta_{\circ} + \alpha_1 GPR_{it} + \beta_2 FDI_{it} + \beta_2 ECG_{it} + \beta_3 BSD_{it} + \beta_4 IFR_{it} + \varepsilon_{it} \quad (2)$$

$$TEC_{it} = \beta_{\circ} + \alpha_1 GPR_{it} + \beta_2 FDI_{it} + \beta_2 ECG_{it} + \beta_3 BSD_{it} + \beta_4 IFR_{it} + \varepsilon_{it} \quad (3)$$

Where FEC is a fossil fuel energy consumption, REC is a renewable energy consumption, and TEC is a total energy consumption. Similarly, other acronyms are as: FDI is a foreign investment, ECG is an economic growth, BSD is a banking development, and IFR is an inflation rate. Equation (1) mainly shows the impact of GPR (geopolitical risk) on FEC, equation (2) shows the impact of GPR on REC, and equation (3) shows the impact of GPR on TEC. The symbol of $\beta_{\circ}$ is used to denote the constant which is an intercept of regression line. Similarly, the symbol of α is vector of coefficient for explanatory variable while β1, β2, β3, β4 are the vectors of coefficient for control variables. The subscripts I is for cross-section and t is for time period. The symbol of ε shows the error term.

These equations were analyzed by employing the FMOLS (Fully Modified Ordinary Least Squares) model, and the robustness of the analysis was assessed using the DOLS (Dynamic Ordinary Least Squares) and ARDL (Autoregressive Distributed Lag) models. We checked the suitability of the underlying models by employing pre-estimation techniques, including the Cross-Section Dependence (CD) test, second-generation unit root test, and cointegration analysis. The adoption of cross-section dependence tests in this research was motivated by panel analysis on a group of BRICS countries that have a high probability of co-dependence. To test this assumption, we used the CD test and presented the analysis in Table 2. The statistical values of CD techniques, including the Breusch-Pagan LM test [33], Pesaran LM test, and Pesaran CD test [34], shown in Table 2, confirm the existence of a CD issue. Due to the CD issue, we employed the second-generation unit root test suggested by Pesaran [35] and reported the analysis in Table 3. The analysis presented in Table 3 demonstrates mixed trends in stationarity, as some variables are stationary at level I(0), while others are stationary at level I (1). To address the presence of stationarity issues, we conducted cointegration analysis by employing the Johansen cointegration test [36] and reported the results in Table 4. The statistical analysis reported in Table 4 assumes the presence of cointegration, which motivated us to estimate the coefficients in the long run.

The motivation for the FMOLS model lies in addressing the shortcomings of traditional OLS (Ordinary Least Squares) regression when dealing with non-stationary time series data. FMOLS is specifically designed for estimating long-run relationships in co-

Table 1
Detail of variables.

Acronym	Variable	Role	Measurement	Reference
FEC	Fossil fuel energy consumption	Dependent	Fossil fuel energy consumption (% of total)	[13,29]
REC	Renewable energy consumption	Dependent	Renewable energy consumption (% of total final energy consumption)	[4,7]
TEC	Total energy consumption	Dependent	Energy use (kg of oil equivalent per capita)	[9,13]
GPR	Geopolitical risk	Independent	GPR index	[4,29]
FDI	Foreign investment	Control	Foreign direct investment, net inflows (% of GDP)	[38,39]
ECG	Economic growth	Control	GDP growth (annual %)	[31]
BSD	Banking sector development	Control	Domestic credit to private sector by banks (% of GDP)	[30]
IFR	Inflation rate	Control	Inflation, consumer prices (annual %)	[32]

Source: Previous studies.

Table 2
Cross-section dependence analysis.

Test	Statistics	D.F	Probability
Breusch-Pagan LM	86.512	10	0.000
Pesaran scaled LM	17.108	–	0.000
Pesaran CD	4.960	–	0.000

Note: The significant p-values probe that there the issue of cross-section dependence exists among the series of variables.
Source: self-elaboration.

Table 3
Second-generation unit root testing.

Variables	(Cross- section IPS)		(Cross-section ADF)	
	At Level	At first difference	At level	At first difference
FEC	(-0.890) 0.186	(-3.749) 0.000***	(15.062) 0.129	(34.127) 0.000***
REC	(-3.003) 0.001***	–	(29.164) 0.001***	–
TEC	(2.164) 0.995	(−3.662) 0.000***	(4.477) 0.923	(32.006) 0.004***
GPR	(-6.357) 0.000***	–	(55.172) 0.000***	–
FDI	(-1.363) 0.086**	–	(17.546) 0.063**	–
ECG	(-1.776) 0.037***	–	(18.353) 0.049**	–
BSD	(0.057) 0.522	(-2.573) 0.005***	(10.083) 0.433	(23.975) 0.007***
IFR	(-7.657) 0.000***	–	(94.254) 0.000***	–

Acronyms: FEC = fossil fuel energy consumption, REC = renewable energy consumption, TEC = total energy consumption, GPR = geopolitical risk, FDI = foreign direct investment, ECG = economic growth, BSD = banking sector development, IFR = inflation rate.
Note: ***, **, * are demonstrating the significance level at 1 %, 5 %, and 10 % relatively.
Source: self-calculation.

integrated data. In addition, FMOLS and DOLS allow to examine the long-term dynamics between variables. Wang et al. [37] employed FMOLS and DOLS models for checking the impact of GPR on resource extraction. Similarly, we employ the ARDL as it is suitable for situations where variables are co-integrated but individually non-stationary. It allows for the estimation of the long-term equilibrium relationship between these variables while considering their short-term dynamics. Rasoulinezhad et al. [8] employed ARDL model while testing the impact of GPR on energy transition. In summary, both the FMOLS and ARDL models are motivated by the need to properly model and estimate long-run relationships between variables in the presence of non-stationarity and cointegration. They provide robust and reliable methods for addressing these issues, making them essential tools in econometrics for understanding economic and financial dynamics.

The selection of these methods is justified based on their distinct advantages and suitability for addressing various aspects of the research question. FMOLS is chosen for its effectiveness in handling potential endogeneity issues and capturing long-term cointegrating relationships. DOLS is employed to investigate dynamic effects, incorporating lagged variables and addressing concerns related to cointegration. ARDL, with its flexibility in accommodating both I(0) and I(1) variables, enables a comprehensive analysis of short-term and long-term impacts. Each method contributes a unique perspective, collectively allowing for a robust assessment of the multifaceted interplay between GPR and energy consumption over the 25-year period from 1998 to 2022. The study aims to provide a nuanced understanding of the impacts, considering both the strengths and limitations of each econometric approach.

Table 4
Cointegration analysis.

Kao Residual Cointegration Test		
Test Name	t-statistics	Probability
ADF	−1.638	0.056
Residual Variance	0.402	–
HAC Variance	0.354	–

Note: the p-value of ADF test is significant at 5 % level, confirming the existence of cointegration.
Source: self-elaboration.

4. Empirical results

4.1. Descriptive and correlation analysis

Table 5 provides a summary of the descriptive analysis of the variables of the study. The mean value of FEC is 77.116 which is the percentage of fossil fuel energy consumption. The mean value of REC is 23.809, showing the percentage of REC in total energy consumption. Both values provide a picture of the energy mix consumed by a country. The mean value of GPR is 0.291, showing the intensity of geopolitical risk. Table 6 shows the correlation analysis. In column 2 of Table 6, REC has a high correlation value of −0.956, showing a strong correlation between both types of energy. The negative sign shows the inverse trend between both types of energy consumption.

4.2. Regression analysis

In our regression analysis, we primarily utilize the FMOLS model, and the results are summarized in Table 7. Specifically, when examining the relationship between GPR and FEC, we find a noteworthy coefficient value of −0.205. Similarly, the coefficient values for GPR with REC and TEC are 0.867 and −0.115, respectively. It's important to highlight that all of these coefficients are statistically significant at the 1 % level. These findings indicate that GPR has a negative impact on FEC and TEC but a positive effect on REC. Moreover, these coefficients reveal the extent of change in dependent variables resulting from a one-unit change in GPR. Moving on to FDI, we observe a positive coefficient with FEC, while it exhibits negative coefficients with REC and TEC. Additionally, ECG displays positive coefficient values with FEC and TEC but holds a significant negative coefficient with REC. Furthermore, our control variables exhibit specific coefficient values, illustrating their asymmetric effects on ECP. Table 8 reports the statistical analysis for DOLS model while Table 9 shows the robustness check when we employ ARDL model. In the subsequent section, we will delve into the interrelationships among these variables.

5. Discussion on results

The findings of study reveal the significant negative effect of GPR on FFE and total energy consumption while a significant positive effect on renewable energy consumption. This specific relationship can be explained as when GPR increases, it tends to have a dampening effect on both fossil fuel energy consumption and total energy consumption. This negative impact could be due to increased uncertainty and instability in global geopolitics, which might discourage investments in fossil fuel-related projects or lead to disruptions in the supply chain of fossil fuels [37]. Consequently, countries may reduce their reliance on fossil fuels, thereby lowering both FEC and TEC. In addition, GPR can create uncertainty and instability in the energy market [8]. When geopolitical tensions rise or there are concerns about energy supply disruptions due to political conflicts, governments and businesses may become cautious about relying too heavily on fossil fuels, which are often subject to international trade and supply chain vulnerabilities. As a result, they may seek to diversify their energy sources away from fossil fuels, leading to reduced consumption of fossil fuels like coal, oil, and natural gas. Moreover, geopolitical tensions can prompt countries to enhance their energy security by reducing reliance on energy imports, especially if they are major importers of fossil fuels. This can involve measures to increase energy efficiency, promote domestic energy production, and diversify energy sources. These actions can lead to a decrease in FEC and TEC.

Conversely, the significant positive effect of GPR on renewable energy consumption indicates that geopolitical risks might incentivize the adoption and development of renewable energy sources. During times of heightened geopolitical instability or concerns about fossil fuel availability, countries may invest more in renewable energy technologies as a way to enhance energy security and reduce reliance on volatile fossil fuel markets [4]. Renewable energy sources, being domestically available and sustainable, contribute to energy independence. Countries may invest more in REC to reduce their vulnerability to international energy supply disruptions caused by geopolitical events. In summary, the negative effect of GPR on FEC and TEC, coupled with its positive effect on REC, reflects how GPR can influence energy consumption patterns. It highlights the complex interplay between energy security, environmental considerations, and the quest for diversified and sustainable energy sources in response to global geopolitical dynamics.

Table 5
Descriptive analysis.

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
FEC	77.116	84.796	92.142	51.318	13.658	−0.630	1.811
REC	23.809	17.280	48.920	3.180	16.798	0.194	1.376
TEC	2102.783	1630.171	5167.010	398.735	1442.328	0.805	2.523
GPR	0.291	0.201	1.140	0.025	0.278	1.129	3.523
FDI	2.335	2.092	5.368	0.205	1.300	0.236	2.001
ECG	4.773	4.823	14.230	−7.799	3.618	−0.316	3.552
BSD	64.170	54.059	165.390	16.823	35.457	1.225	3.644
IFR	5.834	5.181	21.477	−1.401	3.886	1.066	4.975

Acronyms: FEC = fossil fuel energy consumption, REC = renewable energy consumption, TEC = total energy consumption, GPR = geopolitical risk, FDI = foreign direct investment, ECG = economic growth, BSD = banking sector development, IFR = inflation rate.
Source: self-calculation.

Table 6
Correlation analysis.

Variables	FEC	REC	TEC	GPR	FDI	ECG	BSD	IFR
FEC	1.000							
REC	−0.956	1.000						
TEC	0.684	−0.830	1.000					
GPR	0.104	−0.133	0.095	1.000				
FDI	−0.198	0.167	−0.086	0.022	1.000			
ECG	0.170	0.012	−0.284	−0.095	0.165	1.000		
BSD	0.370	−0.263	−0.062	0.049	0.216	0.381	1.000	
IFR	0.013	−0.114	0.332	−0.025	−0.112	−0.284	−0.569	1.000

Acronyms: FEC = fossil fuel energy consumption, REC = renewable energy consumption, TEC = total energy consumption, GPR = geopolitical risk, FDI = foreign direct investment, ECG = economic growth, BSD = banking sector development, IFR = inflation rate.
Source: self-calculation.

Table 7
Effect of geopolitical risk on energy policy.

Variables	FMOLS (fully modified ordinary least square) model					
	FEC as a dependent		REC as a dependent		TEC as a dependent	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
GPR	−0.205***	0.008	0.867***	0.006	−0.115**	0.088
FDI	0.392**	0.071	−0.092**	0.087	−0.064***	0.035
ECG	0.309***	0.046	−0.470**	0.056	0.119***	0.014
BSD	0.132***	0.000	−0.199***	0.000	0.200***	0.000
IFR	−0.302***	0.022	0.556***	0.008	−0.113***	0.021
Adjusted R-squared		0.470	0.451		0.480	
S.E. of regression		2.360	3.704		1.199	
Long-run variance		10.818	27.370		77.581	

Acronyms: FEC = fossil fuel energy consumption, REC = renewable energy consumption, TEC = total energy consumption, GPR = geopolitical risk, FDI = foreign direct investment, ECG = economic growth, BSD = banking sector development, IFR = inflation rate.
Note: ***, **, * are demonstrating the significance level at 1 %, 5 %, and 10 % relatively.
Source: self-calculation.

Table 8
Robustness analysis (effect of geopolitical risk on energy policy).

Variables	DOLS (fully modified ordinary least square) model					
	FEC as a dependent		REC as a dependent		TEC as a dependent	
	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
GPR	−0.371***	0.040	0.843***	0.039	−0.111***	0.008
FDI	0.611	0.369	1.042	0.487	−0.083	0.313
ECG	0.841***	0.034	−0.461**	0.053	0.034***	0.004
BSD	0.180***	0.001	−0.175**	0.064	0.020***	0.002
IFR	−0.635**	0.062	0.413**	0.053	−0.259**	0.081
Adjusted R-squared		0.491	0.478		0.490	
S.E. of regression		1.244	2.438		4.212	
Long-run variance		0.134	0.667		202.900	

Acronyms: FEC = fossil fuel energy consumption, REC = renewable energy consumption, TEC = total energy consumption, GPR = geopolitical risk, FDI = foreign direct investment, ECG = economic growth, BSD = banking sector development, IFR = inflation rate.
Note: ***, **, * are demonstrating the significance level at 1 %, 5 %, and 10 % relatively.
Source: self-calculation.

The positive effect of FDI on fossil fuel energy consumption suggests that an increase in FDI tends to lead to higher utilization of fossil fuels. According to pollution haven hypothesis, the inflow of FDI deteriorates the environmental quality by enhancing the consumption of fossil fuels. FDI often leads to increased industrialization in host countries. Industries typically rely on fossil fuels for energy-intensive processes, which can result in higher fossil fuel consumption [38]. On the other hand, the negative effect of FDI on renewable energy consumption and total energy consumption suggests that FDI tends to suppress the use of renewable energy sources and overall energy consumption. Similarly, the positive effect of economic growth on FEC and total energy consumption, coupled with a negative effect on REC can be explained as economic growth typically leads to higher industrial activity, increased urbanization, and greater consumer demand for energy-intensive products and services. This heightened demand often drives up the consumption of readily available and reliable energy sources like fossil fuels, which are historically abundant and established in energy infrastructures.

Table 9
Robustness Check By employing ARDL.

Variables	ARDL estimation					
	FEC as a dependent		REC as a dependent		TEC as a dependent	
	Coefficient	**Probability**	**Coefficient**	**Probability**	**Coefficient**	**Probability**
Long run equation						
GPR	−0.070**	0.095	0.961***	0.045	−1.675*	0.098
FDI	1.611***	0.010	0.961***	0.045	1.061	0.292
ECG	1.573***	0.000	0.964***	0.044	0.990***	0.000
BSD	0.262***	0.000	0.963***	−0.046	0.295***	0.000
IFR	0.372	0.116	0.964***	0.0452	3.258***	0.001
Short run equation						
COINTEQ01	−0.137***	0.005	0.007***	0.006	−0.055***	0.002
D(GPR)	0.244	0.233	0.092***	0.026	0.585	0.361
D(FDI)	−0.118	0.138	0.230	0.126	0.404	0.296
D(ECG)	−0.036	0.510	−0.072***	0.006	−0.114	0.460
D(BSD)	0.006**	0.077	−0.110**	0.075	−0.875***	0.036
D(IFR)	−0.058***	0.007	0.040	0.178	−0.465***	0.020
C	5.584***	0.000	0.364**	0.053	−0.187***	0.015
Mean dependent variable		0.213	−0.342		32.169	
S.E. of regression		0.770	0.840		52.420	
Akaike info criterion		2.034	2.161		9.578	
Schwarz criterion		3.034	3.161		10.577	
Log likelihood		−68.863	−75.659		−472.450	
Hannan-Quinn criterion		2.439	2.566		9.983	

Acronyms: FEC = fossil fuel energy consumption, REC = renewable energy consumption, TEC = total energy consumption, GPR = geopolitical risk, FDI = foreign direct investment, ECG = economic growth, BSD = banking sector development, IFR = inflation rate.
Note: ***, **, * are demonstrating the significance level at 1 %, 5 %, and 10 % relatively.
Source: self-calculation.

Moreover, economic growth often fosters the expansion of energy-intensive industries such as manufacturing, transportation, and construction [31]. These sectors rely heavily on fossil fuels due to their energy density and ease of use, contributing to increased consumption. In summary, economic growth tends to stimulate the demand for energy, and due to historical infrastructure and economic dependencies, this often leads to increased consumption of fossil fuels and total energy. Meanwhile, the adoption of renewable energy sources may face hurdles in the short term due to various economic, infrastructural, and policy-related factors, resulting in a negative effect on their consumption.

The positive effect of banking sector development on FEC and TEC while having a negative effect on renewable energy consumption can be explained as a developed banking sector provides more efficient access to financing for various economic activities, including energy projects. This increased access to capital makes it easier for businesses to invest in fossil fuel-based energy projects, such as coal or oil extraction, and expands their capacity. This, in turn, leads to higher fossil fuel energy production and consumption. In contrast, the banking sector, in pursuit of stable returns on investments, may exhibit risk-averse behavior. Renewable energy projects, such as solar or wind farms, often involve higher upfront costs and longer payback periods compared to fossil fuel projects [10]. Banks may perceive renewable energy investments as riskier due to uncertainties in energy production and regulatory support. Consequently, they may provide less financing for renewable energy projects which further reduces the consumption of renewable energy.

Lastly, the negative effect of the inflation rate on FEC and TEC, along with a positive effect on REC, can be explained as inflation generally erodes the purchasing power of a currency over time. When inflation is high, the real value of money decreases, making it more expensive to purchase goods and services, including fossil fuels [15]. As a result, the cost of fossil fuels, such as oil and natural gas, tends to rise with inflation. This increase in fossil fuel prices can discourage their consumption because they become relatively more expensive compared to other energy sources. Consequently, higher inflation rates can lead to reduced fossil fuel energy consumption.

In contrast, renewable energy sources like wind, solar, and hydroelectric power are often less sensitive to inflation. Their operating costs are typically lower because they rely on natural resources that are not subject to price inflation. As fossil fuel prices rise with inflation, renewable energy sources may become relatively more attractive due to their stable costs. This can encourage greater adoption and consumption of renewable energy, resulting in a positive effect. In summary, it can be suggested that GPR has a significant implications in determining the energy consumption of a country.

The findings of this study have significant policy implications for BRICS nations, particularly in the realm of energy strategy. The observed negative impact of GPR on fossil fuel and total energy consumption suggests that governments need to develop more resilient energy systems that are less dependent on fossil fuels, especially in times of heightened geopolitical tensions. Policymakers could prioritize the diversification of energy sources, with a strong emphasis on expanding renewable energy infrastructure, as the positive correlation between GPR and renewable energy consumption indicates that geopolitical uncertainty encourages a shift towards renewables. This shift can be leveraged by creating robust incentives and regulatory frameworks to support investments in renewable energy technologies. Additionally, the asymmetric effects of other factors like FDI inflow, economic growth, and banking sector development suggest that a holistic approach is required one that integrates macroeconomic stability, energy security, and sustainable development. In practice, these findings could lead to the development of long-term energy policies that promote energy security, reduce fossil fuel dependence, and encourage renewable energy adoption to mitigate the risks associated with geopolitical disruptions. Furthermore, these insights can guide government initiatives to foster greater collaboration between the private sector and public institutions in building a resilient and sustainable energy future for BRICS nations.

6. Conclusion and policies

In conclusion, our study delved into the intricate dynamics between GPR and energy consumption, offering fresh empirical insights into the BRICS nations. Drawing from a substantial dataset spanning 25 years, covering the period from 1998 to 2022, we employed rigorous analytical techniques, including the FMOLS, DOLS, and ARDL models. The findings illuminate several significant trends in the relationship between geopolitical risk (GPR) and energy consumption within the BRICS context. Notably, we observed a substantial and consistent negative impact of GPR on both FFE and TEC. This suggests that heightened GPR tends to curtail the consumption of fossil fuels, signaling the susceptibility of these nations to external geopolitical factors that influence their energy policies. Conversely, the research uncovered a noteworthy positive association between GPR and REC. This implies that, when faced with elevated geopolitical risk, BRICS countries exhibit an inclination towards the adoption and utilization of renewable energy sources. This observation underscores the adaptability and resilience of these nations in the face of geopolitical challenges, as they pivot towards more sustainable energy alternatives.

Furthermore, our analysis unveiled the presence of asymmetric effects stemming from various economic determinants, such as FDI inflow, economic growth, banking sector development, and the inflation rate, on energy consumption. These nuances underscore the complex interplay between economic factors and energy policy formulation, reinforcing the need for tailored and context-specific strategies within the BRICS nations. In sum, our study contributes to the understanding of the multifaceted relationship between geopolitical risk and energy consumption in the BRICS countries. These findings hold relevance not only for policymakers within these nations but also for global stakeholders seeking to navigate the evolving landscape of energy security and sustainability in an increasingly interconnected world. As geopolitical dynamics continue to evolve, the lessons gleaned from this research can inform strategic decisions and policies aimed at ensuring energy resilience and stability within the BRICS nations and beyond. In summary, the study's findings suggest that BRICS countries should focus on energy diversification, renewable energy promotion, policy resilience, attracting investment, energy efficiency, and geopolitical risk mitigation to develop robust and sustainable energy consumption policies in the face of evolving economic and geopolitical challenges.

6.1. Limitations and future research agenda

Geopolitical risk is a multifaceted concept, and the study may not fully account for the nuanced geopolitical factors specific to each BRICS country. Further research could delve deeper into country-specific geopolitical contexts. The study identifies relationships between GPR and energy consumption policies, but it may not establish causality. Future research could employ more advanced causal inference methods. By addressing these limitations and pursuing this research agenda, future studies can provide a more comprehensive and nuanced understanding of the relationship between geopolitical risk and energy consumption policies in the BRICS nations.

Compliance with ethical standards

Disclosure of potential conflicts of interest

I, acting as corresponding author hereby declare on the behalf of my co-authors that we have no conflict of interest.

Informed consent

I hereby grant the consent and acknowledge that paper should be sent for peer review, or any other publication process required by journal.

Data availability statement

Data that support the findings of this study available at public domains named *World Development Indicators, The World Bank*. Data will be made available on request

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Mosab I. Tabash: Supervision, Project administration, Conceptualization. **Umar Farooq:** Writing – review & editing, Writing – original draft, Conceptualization. **Mamdouh Abdulaziz Saleh Al-Faryan:** Formal analysis, Data curation, Conceptualization. **Wing-Keung Wong:** Validation, Methodology, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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