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ARTICLE

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From resource curse to green growth: Exploring the role of energy utilization and natural resource abundance in economic development

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Abstract

This study delves into the profound repercussions of the resource curse hypothesis within the Brazil, Russia, India, China, and South Africa (BRICS) nations from 1991 to 2022, examining the intricate interplay among natural resource abundance, energy consumption, and economic development (ED). Methodologically, it employs the cross-sectionally augmented Dickey–Fuller test to assess stationarity and utilizes the Westerlund cointegration technique to analyze cointegration. Subsequently, the cross-sectionally augmented autoregressive distributive lag model is deployed to explore the impact of natural resource availability, renewable and non-renewable energy utilization, and carbon emissions on ED within these countries. The findings reveal a stark reality wherein both carbon emissions and non-renewable energy consumption wield a consistently positive influence on short- and long-term economic growth across the BRICS economies. Particularly striking is the dominant impact of non-renewable energy consumption.

However, this comes in stark contrast to the adverse effects identified with excessive resource and coal rents, signifying potential economic setbacks arising from rampant natural resource exploitation. Furthermore, the suboptimal utilization of renewable energy resources hints at a detrimental effect on ED. These results transcend the confines of developing nations, underscoring the universality of the resource curse hypothesis, affecting both developing and developed countries. The study illuminates the grave risks inherent in overreliance and overexploitation of natural resources, elucidating heightened competition that severely impedes the ED trajectory of the BRICS countries in both short and long terms. Policymakers must prioritize economic diversification, implement sustainable resource management, and invest in innovative technologies to mitigate the resource curse in BRICS nations, fostering resilience and sustainable economic growth. In conclusion, This study highlights the severe impact of the resource curse in BRICS nations, stressing the imperative for adept resource management to counter the risks linked with overdependence on non-renewable resources and bolster sustainable economic growth.

KEYWORDS
BRICS, CO_2, economic development, natural resource rents, renewable energy

1 | INTRODUCTION

The debate on the impact of natural resources on economic growth has been ongoing for a long time. According to Ricardo (1911) and Smith (1776a), abundance of natural resources, particularly in the shape of minerals, oil, and gas is considered as imperative elements in the economic development (ED) of any country (Badeeb et al., 2017a, 2017b; Tsani, 2013). Several resource-rich nations in Latin America, Africa, and the Middle East have fallen behind countries with limited natural resources in terms of economic growth in recent years (Badeeb et al., 2017a, 2017b). This concept is what is introduced as the "resource curse hypothesis (RCH)" by Auty (1993). Countries with an abundance of natural resources do poorly economically in comparison to nations with limited natural resources. Researchers in economics, particularly those working in developing nations, are increasingly interested in studying the resource curse, which casts doubts on the traditional view of natural resources as a boon (Apergis & Payne, 2014; Imran & Jijian, 2023; Norman, 2010; Papyrakis & Gerlagh, 2004).

Numerous approaches have been investigated by researchers to ascertain if an excess of natural resources has a resource curse impact on ED (Badeeb et al., 2017a, 2017b). Conventional methods, however, offer shoddy channels for tying the economies to resource-oriented businesses (Prebish, 1950; Wu et al., 2023). Encouraging ED and effectively utilizing natural resources require a stable and effective financial system (Pradhan, Arvin, et al., 2016; Pradhan, Bagchi, et al., 2016). It is impossible to overestimate the significance of ED in getting greater ED (Yang et al., 2024; Yu et al., 2021; Zaidi et al., 2019). For instance, Norway has a prosperous economy largely due to its oil wealth, and the abundance of diamonds has helped Australia, Botswana, and South African economies to grow (Aragona et al., 2015; Boschini et al., 2007; Xu et al., 2020). Numerous studies have examined the relationship between natural resource abundance and ED, both theoretically and empirically. However, the findings and inferences of these researchers portray contradictory and unclear pictures. Several scholars, including Mehlum et al. (2006), Gelb (1988), and Sachs and Warner (2001) have found that countries with adequate natural resources tend to possess worse economic milieu. Corden and Neary (1982) and Elbadawi and Soto (2016) have also reached similar conclusions.

In this regard, the research has been focused on several countries, including Brazil, Russia, India, China, and South Africa (BRICS) countries that are considered to be major emerging economies. Among these countries, China and India have the largest populations with 1.4 billion and 1.38 billion people, respectively. Brazil is the third most populous country in the group, with a population of 202 million, followed by Russia with 144.5 million and South Africa with 60 million people. China's economy is the largest in the group and has contributed significantly to global economic growth, accounting for half of the world's ED in the last 8 years. China's economic growth has been driven by several factors, including its vast manufacturing industry, technological advancements, and a large workforce. India's economy is the second-largest in the group, and it has experienced significant growth in recent years, driven by its service sector, information technology, and manufacturing industries. Brazil's economy is the third-largest in the group, and it has a diverse economy with a strong agricultural sector and a growing service sector. Russia's economy is primarily driven by its natural resources, including oil, gas, and minerals. South Africa has a well-diversified economy, with strong sectors in mining, finance, and tourism. The BRICS countries have become increasingly important players in the global economy, and their collective economic growth is expected to continue to shape the world economy in the coming years (World Bank, 2022; Xi et al., 2023; Xu, Tu, et al., 2023).

It is also important to keep in mind that, although if natural resource endowment might affect ED, a strong financial structure is vital to fostering ED and effective natural resource deployment (Pradhan, Arvin, et al., 2016; Pradhan, Bagchi, et al., 2016; Xu, Qiu, et al., 2023). Therefore, policymakers must consider a range of factors to harness the benefits of natural resource endowment and mitigate the potential negative effects of the resource curse on the economy.

According to the RCH, countries with an abundance of natural resources tend to experience slower economic growth, increased corruption, and weakened democratic institutions (Auty, 2001; Ross, 2015; Wen et al., 2024). India and China, as two examples of resource-rich countries, have faced challenges in managing their energy resources sustainably. According to the International Energy Agency (IEA) (2023), India is anticipated to overthrow the Chinese economy as the Asian primary mode of growth in future energy demand. Primary energy sources used globally consist of electricity and various fuels such as coal, oil, gas, and biomass. Although most energy end-users lack access to energy sources directly. However, the masses rely on secondary sources of energy, which are stored forms of energy derived from primary energy sources, such as liquid fuels and electricity. The total final energy consumption of end-use sectors is reflected by the demand for energy carriers (Thomas & Haigh, 2017). In India, coals comprised 44% of its main source of energy in 2017–2018, accompanied by oil products (34%), hydropower (13%), natural-gas (7%), and lignite (7%). In the same year, the country produced the most electricity from crude coal (64.28%), natural gas (37.75%), and lignite (83.67%), Government of India (2019). Approximately 45% of India's energy needs are met by renewable sources, with hydroelectricity increasing quickly throughout the nation (Pao & Fu, 2013). However, despite its potential, the growth of hydropower has been restricted by environmental concerns, such as the displacement of indigenous communities and damage to ecosystems (Gelcich et al., 2019; Wahab et al., 2023; Zhou, Zhou, et al., 2021). Additionally, the infusion of multinational investors has led to concerns about the potential for these companies to exploit Brazil's resources and contribute to corruption (Branco & Pires, 2019). Similarly, China's reliance on coal as its primary energy source has contributed to environmental degradation and public health concerns, leading to growing calls for transition to cleaner energy sources (Wahab et al., 2024; Zheng, Yin, et al., 2021; Zhou, Deng, et al., 2021). The rapid growth of China's economy and energy consumption has led to a widening disparity among demand and supply energy (Samour et al., 2022; Zheng, Liu, Ni, et al., 2021). Furthermore, the lack of transparency in China's extractive industries has contributed to corruption and weakened democratic institutions (Fan & Hao, 2020a; Fan & Hao, 2020b; Zhang, Chen, et al., 2020, Zheng, Liu, & Yin, 2021).

Brazil, Russia, and South Africa are also significant players in the global energy landscape, and their energy policies are worth examining in the context of global energy developments. Brazil's energy sector is dominated by hydropower, which accounts for over 60% of its total electricity generation (IEA, 2021a; Wen et al., 2024). Brazil is also one of the world's largest producers and exporters of biofuels, particularly ethanol made from sugarcane (IEA, 2021a; Wang et al., 2023). Russia is a major producer and exporter of oil and natural gas, and these fuels account for the majority of its energy production and consumption (IEA, 2021c; Wang et al., 2020). In recent years, Russia has also increased its investment in renewable energy, particularly in wind and solar power (IEA, 2021c). South Africa's energy sector is characterized by a heavy reliance on coal, which accounts for over 80% of its total electricity generation (IEA, 2021d; Sun et al., 2021). However, South Africa has also made significant investments in renewable energy, particularly in wind and solar power, and has set a target of generating 17.8 GW of renewable energy by 2030 (IEA, 2021d).

While Brazil, Russia, and South Africa also face their own unique challenges in balancing ED and environmental sustainability. In Brazil, deforestation and the burning of biomass for energy production have contributed to high levels of greenhouse gas emissions, and the country has faced criticism for its environmental policies (IEA, 2021a). Russia's heavy reliance on oil and gas exports leaves it vulnerable to fluctuations in global energy prices, and the country has been criticized for its lack of investment in renewable energy (IEA, 2021c). In South Africa, the high cost of electricity and the country's dependence on coal have hampered efforts to transition to a more sustainable energy system (IEA, 2021d). Overall, the global energy landscape is complex and multifaceted, with different nations facing their own unique challenges and opportunities. As the world continues to grapple with the challenges of climate change and the need for sustainable development, countries must cooperate to discover solutions that are good for the environment and the economies.

This study aims to contribute to the literature on the RCH by examining the relationship between non-renewable and renewable energy sources, energy consumption, and ED in BRICS countries between 1991 and 2022. Specifically, this study seeks to investigate whether the RCH holds true in the case of these countries, wherein an abundance of natural resources may lead to economic challenges and underdevelopment. Our study's primary focus is to examine the effect of coal and fossil fuel utilization on ED and energy consumption in the BRICS countries. We will also employ a "cross-sectionally enhanced Dickey Fuller" test to decide the level of stationarity, and "Westerlund's cointegration" a method for examining how energy usage and its effects are cointegrated. Eventually, the Common Correlated Mean Group model is employed to check robustness of our results.

To achieve this goal, we will first review existing literature on the RCH in Section 2. We shall describe the conceptual framework we used to investigate the relationship among sources of energy, energy consumption, and ED in Section 3. In Section 4, we will describe the estimation method used to test the hypothesis, and in Section 5, we will present the empirical findings of our analysis. In Section 6, we will discuss the findings of our analysis for each country, and in Section 7, we will conclude by discussing the policy implications of our study's results. Overall, by presenting actual data on the correlation among sources of energy, energy use, and economic growth in a few chosen nations, our research aims to add to the continuing discussion on the resource curse concept.

2 | LITERATURE REVIEW

The conventional studies on resource abundance typically perceive natural resources as a driving force for economic growth. However, the emergence of the "Resource Curse" and "Dutch Disease" hypotheses highlights how abundant resources might hinder a country's economic progress. Recent research points to factors like inadequate literacy, inefficient institutional management, short-term thinking, rent-seeking behavior, and the “Dutch Disease” as key contributors to this paradoxical phenomenon (cqgz & Ntow-Gyamfi, 2018a, 2018b, 2018c; Sachs & Warner, 2001; Shahbaz et al., 2018). Beck and Poelhekke (2017) have demonstrated the likelihood of the Resource Curse in countries with extensive natural resources.

2.1 | Natural resource wealth and its impact on ED

Classical economic theorists like Ricardo (1911) and Smith (1776b) advocated that nations endowed with abundant natural resources would witness rapid economic growth. However, the 1970s and 1980s saw the real exchange rate devaluation, favoring The Netherland's trade advantage, challenging this belief (Samour et al., 2023; Shang & Luo, 2021; Zhang & Brouwer, 2019). Instead of transforming these resources into goods, resource-rich nations leaned on exporting raw materials (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Qiao et al., 2023; Sachs & Warner, 2001). While this boosted export profits and global competitiveness, it complicated long-term industrial planning, ultimately stalling economic growth, diminishing diversity, and threatening growth potential (Gylfason, 2001; Ma et al., 2021; Mou & Bai, 2018).

At the heart of the resource curse lies rent-seeking behavior, generating negative macroeconomic consequences known as the “Dutch disease” in resource-rich nations. The exploitation of natural resources often triggered increased rent-seeking and corruption, impeding economic growth (Humphreys et al., 2007; Wahab et al., 2023; Yuxiang & Chen, 2010a, 2010b).

Initially, the resource abundance hypothesis suggested that countries rich in natural resources should experience heightened economic growth. However, studies often revealed the contrary: resource-rich nations experienced slower economic growth and development. Dwumfour and Ntow-Gyamfi (2018a, 2018b, 2018c) attributed the resource curse to factors like illiteracy, ineffective institutional management, short-term thinking, reliance on rent-seeking, and Dutch disease. This suggests that effectively managing abundant natural resources could pose a challenge, leading to economic homogeneity. Moreover, Sachs and Warner (2001) found that countries heavily dependent on resource exports often encountered more volatile economic growth and slower development due to fluctuating global prices of natural resources, fostering an over-reliance on these exports and hindering the growth of other sectors.

Furthermore, Gylfason (2001) argued that the resource curse could stifle economic diversification, making non-resource industries less competitive, culminating in a stagnant economy. The quality of institutions also plays a pivotal role in alleviating the resource curse's effects. Biswas et al. (2014) noted that improved institutional quality mitigated the negative consequences of resource abundance on ED. Effective institutions, as argued by Amin and Djankov (2009) and Djankov et al. (2005), facilitate smooth contracts and accessible investment opportunities, fortifying the economic structure of resource-rich countries.

In summary, while the resource abundance hypothesis suggested heightened economic growth for nations with abundant natural resources, the resource curse phenomenon presented a contrasting reality. Studies highlighted factors like ineffective institutional management, over-reliance on resource exports, and lack of economic diversity contributing to the resource curse. Effective institutions and policies might help mitigate the adverse effects of resource abundance on ED.

2.2 | Nexus among energy utilization, CO_2, and ED

Recent advancements in research have sharpened the focus on understanding the intricate relationship among ED, energy usage, and the concerning issue of air pollution. Wahab et al. (2024) delved into the data of G-7 markets spanning from 1990 to 2012, employing the comprehensive cross-sectionally augmented autoregressive distributive lag (CS-ARDL) approach. Their findings revealed a notable negative correlation between energy output and carbon emissions. However, the research also underscored positive correlations with technological innovation and exports, shedding light on the complex interplay between ED and its environmental implications. It became apparent that while economic growth and trade might contribute to prosperity, they also carry a potential for exacerbating global warming. Expanding this scope, the examination of BRICS countries from 1995 to 2018 by Wahab et al. (2022) uncovered a multifaceted correlation matrix. Here, a negative relationship emerged between exports and carbon emissions, contrasting with a positive correlation observed between renewable energy consumption and greenhouse gas emissions. Additionally, the research revealed a robust association between greenhouse gases, imports, and the trajectory of ED within these nations.

Ang (2007) meticulously explored French data dating from 1960 to 2000, unearthing a sustained correlation between ED, energy consumption, and pollution. The study illuminated a consistent long-term relationship, intertwined with a short-term unidirectional causal link specifically between ED and energy usage. Building upon this understanding, Ang (2009) meticulously scrutinized the dynamic interrelationship in China utilizing the DOLS approach. Their study disclosed a correlation between trade openness, flexibility in carbon pollution, and their constructive influence in curbing greenhouse gas emissions.

Soytas et al. (2007) took the mantle to decipher the complex web between energy utilization, CO_2 emissions, and the economic well-being of the United States. Their comprehensive Granger causality test illuminated a significant finding: while energy consumption leads to increased carbon emissions, it does not necessarily guarantee economic prosperity. Halicioglu's (2009) insightful investigation into Turkish data from 1960 to 2005 brought to the fore a compelling long-term impact of greenhouse gas emissions on not just energy consumption but also income and international commerce. The study underscored the pressing need to integrate environmental concerns into Turkey's macroeconomic strategies to effectively curb carbon emissions and sustain economic growth.

Further expanding the research landscape, Cowan et al. (2014) meticulously probed into the causal relationships intertwining energy consumption, ED, and CO_2 emissions across BRICS nations. Their study highlighted the presence of cross-sectional dependency across these nations. In their findings, they discerned a one-way relationship between ED and CO_2 emissions in South Africa, while Brazil exhibited a scenario where emissions directly influenced the trajectory of ED.

Additionally, Sebri and Salha (2014) undertook a comprehensive analysis encompassing the period from 1971 to 2010, dissecting the intricate web of relationships among ED, consumption of renewable energy, international trade volumes, and CO_2 emissions within the BRICS. Their research brought forth a compelling bidirectional link between the consumption of renewable energy and the trajectory of ED, emphasizing the critical role of environmental and economic policies in these nations. This emphasis was particularly laid on the imperative integration of renewable energy sources to foster sustainable economic growth and environmental conservation within the BRICS framework.

3 | THEORETICAL FRAMEWORK AND EMPIRICAL MODELING

The factors that influence ED include natural resource availability, use of consumption of renewable energy, and non-renewable energy consumption, as well as the pace of ED (Hoshmand et al., 2013; Ibrahim & Alagidede, 2018; Magazzino et al., 2023; Rajan & Zingales, 2003; Yuxiang & Chen, 2010a, 2010b). Recent research indicates that the supply of natural resources and the ratio of consumption of renewable energy play a significant role in determining the financial stability of countries (Shen et al., 2021; Li et al., 2021, 2022). In spite of the fact that carbon emissions are correlated with natural resource use in every nation (Badeeb et al., 2017a, 2017b; Magazzino, 2023; Smith, 1812; Tiba & Frikha, 2019a, 2019b; Viner, 1952), renewable and non-renewable energy usage are essential for efficient natural resource application. Additionally, in few countries and regions, the amount of natural resource is inversely related to ED, supporting the resource curse argument (Li, Zhang, et al., 2023; Magazzino & Mele, 2022; Ojekemi et al., 2023; Shahbaz et al., 2018).

According to Beck (2002), natural resource may cause a decrease in consumption and savings rates, both of which have a heavy effect on ED. In a similar vein, Rajan and Zingales (2003) provide the organized interest hypothesis of ED, which posits that established monopolies oppose ED as a means of protecting their market share from new entrants. The industrial sector, trade, and other economic aspects suffer greatly in countries with high natural resource levels because of the slower growth, less economic reforms, and unfavorable business environment. This is often observed in resource-rich nations where over-reliance on resource exploitation stunts economic diversification and growth (Humphreys et al., 2007; Sachs & Warner, 2001). Energy sources can potentially accelerate the pace of ED in a country. Coal and oil-fired power plants produce heat, that is converted into steam to generate electricity. However, the burning of oil and coal plants emits a significant amount of carbon, contributing to climate change. The release of carbon emissions traps heat in the atmosphere, which leads to global warming (IEA, 2021b; Lei et al., 2021; Li, Wang, et al., 2023).

To achieve sustainable development, it is necessary to consider various factors, such as the optimal rate of resource rent, carbon dioxide emissions, coal rents, renewable energy utilization, and fossil-fuel utilization when analyzing the relationship between natural resource abundance and ED (Luo et al., 2023, 2024; Shahbaz, 2019). Incorporating these factors into the analysis can help to determine the influence of natural resource abundance on ED in a given economy (Imran, Sattar, et al., 2022; Liu et al., 2021; Lu et al., 2021). For instance, research has shown that the relationship between Natural Resource abundance and ED is complex and can be influenced by a variety of factors, such as the governance quality of the country, the level of corruption, and the presence of rent-seeking behavior. There are also instances when the availability of natural resource may have unfavorable effects, such as the "resource curse," in which nations rich in natural resources face slower economic growth due to an overreliance on exploiting these resources (Ross, 1999). Nations experiencing the resource curse often struggle to diversify their economies, leading to vulnerability when global resource prices fluctuate, hampering overall economic growth.

$$\begin{aligned}\text{Economic development} = f(&\text{rate of resource rents, coal rents, renewable energy utilization,}\\ &\text{fossil fuel utilization, carbon dioxide emission}).\end{aligned} \tag{1}$$

It is crucial to study the connection between any country's Natural Resources and its ED in Equation (1). Annual Gross Domestic Product over a given time period is a typical metric of ED. Carbon dioxide emissions are used to indicate a country's total carbon emissions. The consumption of renewable energy resources is also an important factor in ED, with renewable energy utilization as a percentage of ED yearly being a commonly used measure. Incorporating these factors into an analysis of the influence of natural resource abundance on ED can provide a comprehensive framework for understanding the relationship between these variables. Equation (2) represents the pragmatic form of the ED function used in the examination, where the majority of the data is sourced from the World Development Indicators (2023). The equation relates the economic progress of a country denoted by ED to various factors such as the rate of resource rents, coal rents, renewable energy utilization, fossil fuel utilization, and carbon emissions.

$$\begin{aligned}\text{Economic development}_{it} = {}& \Phi 0 + \Phi 1\,\text{rate of resource rents}_{it} + \Phi 2\text{coal rents}_{it} + \Phi 3\text{renewable energy utilization}_{it}\\ &+ \Phi 4\text{fossil fuel utilization}_{it} + \Phi 5\,\text{carbon dioxide emission}_{2it} + \theta_{it}.\end{aligned} \tag{2}$$

The coefficients Φ0, Φ1, Φ2, Φ3, Φ4, and Φ5 represent the respective impacts of each factor on economic progress, while the error term θit captures the random disturbance in the model. Rate of natural resource rents has been determined to adversely impact ED owing to their rapid price growth and lack of regulation, at least within the hypothetical context. This aligns with the core ideas of the RCH, illustrating that countries overly dependent on natural resource rents often face economic challenges due to the over-reliance on these resources. Over time, this reliance significantly limits economic diversification, thereby hindering sustainable growth.

In the short term, a country's ED suffers due to the ongoing rise in rate of natural resource rents prices ($\Phi1 = $ ED/rate of natural resource rents < 0). However, due to the peaked price level, nations often start shifting their resources towards renewable energy utilization, aiming to break away from the resource curse effects (Imran et al., 2019; Jiang & Xu, 2023). This shift results in a decrease in rate of natural resource rents utilization and a positive effect on ED, attempting to diversify the economic base and mitigate the negative impacts of over-reliance on finite resources (Hanif, 2017; 2019; Imran & Jijian, 2023; Kong et al., 2023).

Therefore, it is expected that $\Phi2 = $ ED/coal rents < 0 in the short run and $\Phi2 = $ ED/coal rents > 0 in the long run, indicating an attempt to diversify the economic base and move away from a singular dependence on certain natural resources (Huang et al., 2020).

Moreover, renewable energy utilization is anticipated to have a positive effect on ED, reflecting the RCH's emphasis on economic diversification. Renewable energy sources, such as wind, hydroelectric, solar, biofuel, and geothermal, offer economic opportunities without the environmental drawbacks of fossil fuels (He et al., 2021; Imran & Jijian, 2023). This diversification not only supports sustainable development but also reduces vulnerability to resource price fluctuations, a common challenge in resource-dependent economies. Therefore, $\Phi3 = $ ED/renewable energy utilization > 0, signifying the importance of diversification in fostering sustained economic growth (Ali et al., 2021; Khan et al., 2022; Zhao et al., 2022).

Conversely, fossil-fuel utilization as sources of non-renewable energy, also aligns with resource curse theory (Kumar et al., 2022; Mohammed et al., 2022; Zhou, Li, et al., 2021). In the short run, fossil-fuel utilization is expected to have a positive effect on ED due to existing infrastructure and employment generated. However, in the long run, it is expected to have a negative impact as nations realize the sustainability limitations and adverse environmental effects (Chen et al., 2024). This negative impact reflects the challenges posed by over-reliance on finite fossil fuels, hindering long-term growth prospects ($\Phi4 = $ ED/fossil-fuel utilization > 0 in the short run and $\Phi1 = $ ED/fossil-fuel utilization < 0 in the long run).

Finally, carbon dioxide emissions are expected to have a positive effect on ED in the short run, illustrating how new industries initially contribute to employment opportunities and economic activity. However, in the long run, the RCH suggests that these emissions might harm sustainable development objectives. Nations with high carbon emissions often face challenges in sustaining economic growth due to environmental concerns and international regulations. Therefore, while $\Phi5 = ED/CO_2 > 0$ in the short run, in the long run, $ED/CO_2 < 0$, signifying the limitations posed by environmental impacts on sustained growth.

4 | ECONOMETRIC STRATEGIES

The study on the RCH within the BRICS nations will commence its analyses by examining slope heterogeneity, aiming to determine whether the data exhibit uniform distribution or not. To ensure robust and efficient results, the investigation will conduct tests for heterogenous slope coefficients as proposed by Pesaran and Yamagata (2008) (Equations 3 and 4), and for cross-sectional dependency, following Pesaran (2004) (Equation 5). These tests are imperative to understand how the variables behave across BRICS nations and to assess if there's a shared pattern or divergent tendencies among them.

Subsequently, the study will address the issue of stationarity, examining the independence of cross-sections and the absence of spillover effects. This analysis will test the null hypothesis suggesting that BRICS nations are individually self-reliant and possess the capacity to withstand economic fluctuations both domestically and internationally. Before applying unit-root, co-integration, or long-run estimation methods, it is critical to resolve these concerns using the aforementioned econometric tools. Failing to address these issues could potentially skew the findings and lead to misleading conclusions regarding the RCH within the BRICS context.

$$\tilde{\Delta}_{\text{slope}-\text{heterogeneity}} = (N)^{\frac{1}{2}}(2k)^{-\frac{1}{2}}\left(\frac{1}{N}\tilde{S}-k\right). \tag{3}$$

Instead, Equation (4) may be used to calculate the revised delta tilde.

$$\tilde{\Delta}_{\text{adjusted}-\text{slope}-\text{heterogeneity}} = (N)^{\frac{1}{2}}\left(\frac{2k(T-k-1)}{T+1}\right)^{-\frac{1}{2}}\left(\frac{1}{N}\tilde{S}-2k\right). \tag{4}$$

And CSD is given as.

$$\text{CSD}_{\text{LM}-\text{adjusted}} = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{k=i+1}^{N}\hat{\gamma}_{ik}\right)\frac{(T-j)\hat{\gamma}_{\text{ik}}{}^{2}-E(T-j)\hat{\gamma}_{\text{ik}}{}^{2}}{V(T-j)\hat{\gamma}_{\text{ik}}{}^{2}}. \tag{5}$$

In examining stationarity, this research employs the “cross-sectional augmented Im, Pesaran, and Shin (CIPS)” technique introduced by Pesaran (2007) (Equation 6). This method has been selected for its capacity to address cross-sectional dependence and diverse slope coefficients, offering more effectiveness compared to traditional panel unit-root tests that focus on singular problems. The application of the CIPS test is particularly relevant within the study of the RCH in the BRICS nations, as it helps assess the stability of key economic indicators across these countries. The typical mathematical expression of the CIPS test allows for a comprehensive evaluation of stationarity in the context of BRICS economies.

$$\widehat{\text{CIPS}} = \frac{1}{N}\sum_{i=1}^{N}\text{CADF}_{\text{i}}. \tag{6}$$

Similarly, the error-correcting mechanism cointegration technique by Westerlund (2007) (Equations 7–10) holds significance within this study. Its application proves valuable in generating reliable outcomes, especially when dealing with varied slope coefficients and cross-sectional dependence, aligning with the complexities often observed in analyses related to the RCH in the BRICS countries.

$$G_{\text{t}} = \frac{1}{N}\sum_{i=1}^{N}\frac{\alpha_i}{\text{SE}\alpha_{\text{i}}} \tag{7}$$

$$G_t = \frac{1}{N}\sum_{i=1}^{N}\frac{T\alpha_{\text{i}}}{\alpha_{\text{i}}(1)} \tag{8}$$

$$P_t = \frac{\alpha}{\text{SE}(\alpha)} \tag{9}$$

$$P_{\text{t}} = T\alpha. \tag{10}$$

To analyze the long-run and short-run associations between ED, rate of natural resource rents, coal rents, renewable energy utilization, fossil-fuel utilization, and carbon dioxide emissions, this study utilizes the CS-ARDL test. Recognizing that traditional methods may yield biased outcomes, the CS-ARDL estimator was employed to assess the short-run and long-run impact of rate of natural resource rents, coal rents, renewable energy utilization, fossil-fuel utilization, and carbon dioxide emissions on ED in the BRICS countries. The CS-ARDL method is preferred due to its capacity to address issues of endogeneity and heterogeneity, ensuring robust outcomes, especially in the context of cross-sectional dependency (Baltagi et al., 2015). By introducing averages for every cross-section, it effectively deals with the challenges posed by cross-sectional dependency.

This analysis aligns with the exploration of the RCH in the context of BRICS countries. The utilization of CS-ARDL allows for a more nuanced understanding of how the abundance and utilization of natural resources—such as rate of natural resource rents and coal rents—interact with ED. By investigating these variables in both short-run and long-run contexts, this study aims to uncover potential effects on economic growth and diversification within these resource-rich economies. Additionally, by incorporating renewable energy utilization and fossil-fuel utilization, which represent both renewable and non-renewable energy usage, the study aims to delineate the intricate relationship between energy usage patterns and ED. Carbon dioxide emissions, while often considered detrimental in the long run, may initially exhibit a positive impact on ED due to the industrial growth associated with increased emissions. However, these emissions may ultimately hinder sustainable development goals, contributing to the broader resource curse narrative evident in nations overly reliant on resource exploitation for economic growth.

$$\Delta \mathrm{ED}_{i,t} = \theta_i + \sum_{l=1}^{p} \pi_{il} \Delta \mathrm{ED}_{i,t-l} + \sum_{l=0}^{p} \pi'_{il} X_{i,t-l} + \sum_{l=0}^{1} \pi'_{il} \overline{Z}_{i,t-l} + \varepsilon_{i,t}. \tag{11}$$

The average values for each cross-section are represented by $\overline{Z}_t = \left(\Delta\overline{\mathrm{GDP}}_t, \overline{X}'_t\right)'$. Additionally, to ensure the reliability of the findings, this study employs the common correlated effect mean group method proposed by Pesaran (2006), which is effective in addressing issues of cross-sectional dependency and heterogeneity.

5 | EMPIRICAL RESULTS

The descriptive statistics, as elucidated in Table 1, encapsulate a detailed spectrum of fundamental economic and environmental indicators relevant to the BRICS nations. These metrics, drawn from the World Development Indicators (2023), offer a comprehensive overview of critical factors pivotal for evaluating economic progress, resource management, and environmental impact within these countries.

Delving into these statistics, they unveil a panorama of ED levels across the BRICS nations. The variance in indicators like ED signifies a diversified economic status quo, underscoring the heterogeneity in growth trajectories and economic standings among these countries.

This dataset further provides valuable insights into the utilization of both renewable and non-renewable resources. Metrics such as Rate of natural resource rent, Renewable energy utilization, Fossil fuel utilization, and Coal rents unveil the varied dependency on these resources within the BRICS countries. The different mean values and standard deviations depicted across these indicators accentuate divergent reliance, extraction methodologies,

TABLE 1 Descriptive statistics.

	Economic development	Rate of natural resource rent	Renewable energy utilization	Fossil fuel utilization	Coal rents	Carbon dioxide emissions
Number	165	165	165	165	165	165
Mean	27.5313	24.32934	5.600207	23.15847	−1.35975	13.88354
Median	27.43304	24.28539	5.56102	23.33838	−.4946149	14.01042
SD	1.149428	1.218857	0.7013453	1.630525	2.627852	1.118276
Skewness	0.5504038	0.2435187	−0.1963778	−0.223064	−1.681506	0.4269501
Kurtosis	2.895684	2.036962	2.061599	2.281849	5.68944	2.226447

and resource management practices among the member nations. For instance, while there seems to be consistent reliance on renewable energy sources, the relatively higher mean values in fossil fuel utilization suggest a significant dependency on non-renewable energy sources, albeit with varying degrees across these nations. The indicators for coal rents also exhibit diverse economic implications, hinting at disparities in profitability or expenses incurred from coal extraction activities across the BRICS countries.

Moreover, the statistics portraying Carbon dioxide emissions shed light on the environmental impact stemming from industrial activities within these nations. The relatively consistent emission levels across the BRICS countries, as reflected by the standard deviation, imply similarities in industrialization patterns. However, it also hints at potential differences in emission control measures implemented by each country to manage environmental consequences.

The data drawn from the World Development Indicators (2023) represents a robust selection of parameters measuring ED, natural resource utilization encompassing both renewable and non-renewable sources, and the subsequent environmental footprint across the BRICS countries. These statistics effectively capture the diverse dynamics at play within these nations, spotlighting the intricate relationship between resource management, economic growth, and environmental sustainability within the broader context of the BRICS economies.

Table 2 presents the empirical results of the "CIPS" test. The findings reveal that only two variables, namely rate of natural resource rents and coal rents, exhibit stationarity at the level, while the variables ED, renewable energy utilization, and fossil-fuel utilization display stationarity at first difference. This suggests that these variables' means do not revert to zero. Moreover, there is no correlation between the rates of change of ED, rate of natural resource rents, coal rents, renewable energy utilization, fossil-fuel utilization, and carbon dioxide, showing that these parameters vary depending on the number of cross-sections. Hence, the majority of the chosen components end up being stationary after only the first difference. Additionally, this outcome might substantiate the RCH, indicating that heavy reliance on natural resources for economic growth could lead to a lack of diversity and sustainability, potentially impacting the stationarity of these variables. After these initial assessments, a test for co-integration is performed.

TABLE 2 Unit-root test.

	Trend and intercept			
	I(0)		*I*(1)	
Statistics	**Statistic**	***p*-Values**	**Statistic**	***p*-Values**
Economic development	−1.990	.3252	−2.991	.0000
Rate of natural resource rents	−2.943***	.001	–	
Renewable energy utilization	−1.915	.4352	−4.008	.0000
Coal rents	−2.914***	.0000	–	
Fossil fuel utilization	−0.910	.4323	−6.040	.0000
Carbn dioxide emissions	−2.006	.2143	−3.951	.0002

Note: The significance levels for 1%, 5%, and 10% are shown by the letters ***, ** and *.

TABLE 3 Co-integration test.

Statistics	**Value**	***p*-Value**
G_t	−3.084	.080
G_a	−12.043	.604
P_t	−5.909	.070
P_a	−13.071	.079

Table 3 reflects the outcomes of a co-integration test utilizing an error-correcting mechanism. The outcomes of the group and panel statistics, namely G_t, G_a, P_t, and P_a, are also presented. The findings demonstrate that in all of the nations considered, ED, rate of natural resource rents, coal rents, renewable energy utilization, fossil-fuel utilization, and carbon dioxide have a long-term co-integrating connection. This persistent connection implies that these variables move together in the long term. The confirmation of a long-term relationship among these factors can lend support to the RCH, indicating that heavy reliance on natural resources for economic growth could lead to a lack of diversity and sustainability, potentially influencing the co-integration of these variables. Long-term cointegration between these variables has been confirmed at the 0.01% level of significance. Since a long-term co-integrating relationship exists, we can proceed with examining both the short-term and long-term relationships.

The analysis in this research starts by running the Pesaran and Yamagata (2008) tests for heterogeneity of slope-coefficients as well as the Pesaran (2004) test for cross-sectional dependence. As evidenced by $\tilde{\Delta}$ and $\tilde{\Delta}_{\text{Adjusted}}$, which have values of 12.096 and 14.059, respectively, Table 4's empirical results demonstrate that the BRICS economies have distinct slope coefficients. This suggests that BRICS nations exhibit heterogeneity concerning ED, rate of natural resource rents, coal rents, renewable energy utilization, fossil-fuel utilization, and carbon dioxide. Moreover, the lower section of the table presents the results of the cross-section dependence test, which supports the notion of cross-sectional dependence among the BRICS economies. This implies that independence is infrequent in the current era, and the majority of economies are interrelated.

These findings on the heterogeneity of variables within the BRICS nations can be intertwined with the RCH. The distinct slope coefficients and cross-sectional dependence suggest that these countries might face challenges due to heavy reliance on natural resources for economic growth. This overdependence might contribute to the lack of diversity and sustainability, affecting the economic variables examined. The unit root test results of this study are presented in Table 4 as the subsequent stage, contributing to our understanding of the long-term relationships among these economic factors.

The results derived from Table 5 via the CS-ARDL model underscore the prevalence of a resource curse within the BRICS nations. These findings demonstrate a significant negative influence on ED attributed to rate of natural resource rents, renewable energy utilization, and coal rents within these countries. This corroborates earlier insights by scholars (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Sachs & Warner, 2001), highlighting the detrimental repercussions of resource abundance on economic advancement. This negative correlation indicates heightened competition and overexploitation of natural resources, emphasizing the potential pitfalls of resource abundance on economic growth (Beck & Poelhekke, 2017; Imran, Ali, et al., 2022).

The analysis reveals that an increase in rate of natural resource rents adversely impacts the ED of BRICS nations, with a unit rise leading to a 4.1% decline in growth. This parallels the RCH, indicating the adverse effects of excessive

TABLE 4 Heterogeneity and CSD.

Statistic	Value	*p*-Value
Economic development	17.181	.0000
Rate of natural resource rents	8.082	.0000
Carbon dioxide emissions	8.939	.0000
Coal rents	12.568	.0000
Renewable energy utilization	−3.051	.0000
Fossil fuel utilization	1.651	.0000
Heterogeneity/homogeneity check		
$\tilde{\Delta}$	12.096	.0023
$\tilde{\Delta}_{\text{Adjusted}}$	14.059	.0000

Note: Following the null-hypothesis of CSD, CSD N(0,1).

TABLE 5 Cross-sectionally augmented autoregressive distributive lag.

Variable	Coefficient	Long run results	
Shortrun result		Error-correcting mechanism (−1)	−.9110010**** (0.0696761)
Rate of natural resource rents	−.0413321*** (0.0112251)	Rate of natural resource rents	−.0438830*** (0.0127410)
Renewable energy Utilization	−.0494101*** (0.0213290)	Renewable energy Utilization	−.0921430** (0.0295050)
Coal rents	−.0287871*** (0.0121311)	Coal rents	−.0332340*** (0.0311011)
Fossil fuel utilization	.2112121*** (0.0513111)	Fossil fuel Utilization	.2210120*** (0.0192410)
Carbon dioxide emissions	.313181*** (0.1032631)	Carbon dioxide emissions	.3413251*** (0.1229110)

Note: Standard errors in parentheses ***$p < .01$, **$p < .05$, *$p < .1$.

resource rent exploitation on economic growth (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Sachs & Warner, 2001). Similarly, the reduction of ED by 4.9% due to increased renewable energy utilization underscores mismanagement of renewable energy sources, aligning with previous research emphasizing effective resource utilization (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Sachs & Warner, 2001).

The adverse impact on ED induced by coal rents, causing a 2.8% reduction with its excessive utilization, aligns with the notion of economic stagnation due to excessive reliance on resources (Gylfason, 2001). Moreover, the linkage between the exploitation of non-renewable resources (rate of natural resource rents and coal rents) and the growth limitations of BRICS economies echoes the RCH. This suggests that a heavy reliance on non-renewable resources might impede economic progress (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Sachs & Warner, 2001).

Conversely, fossil-fuel utilization demonstrates a positive impact on the ED of BRICS countries, supporting the idea that specific non-renewable resources might contribute positively to economic growth (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Sachs & Warner, 2001). Similarly, the positive correlation between carbon emissions and ED resonates with earlier research on emissions' role in fostering economic activities and manufacturing capacity (Ang, 2007; Cowan et al., 2014).

This intertwined relationship among resource utilization, economic growth, and environmental implications signifies the intricate dynamics shaping ED in BRICS countries. The findings underscore the necessity for efficient resource allocation and management, echoing literature emphasizing the adverse impacts of excessive reliance on non-renewable resources (Wang et al., 2025). Effective policy frameworks and institutional structures, as highlighted by various researchers (Biswas et al., 2014; Djankov et al., 2005), may play a crucial role in mitigating the adverse effects of resource abundance on ED.

In conclusion, these results highlight the critical role of resource management in shaping ED. They further strengthen the RCH, illustrating the potential for both positive and negative economic outcomes associated with heavy dependence on non-renewable resources, as identified in previous research (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Gylfason, 2001; Sachs & Warner, 2001).

The long-term results exhibit a consistent pattern for all variables, suggesting that the RCH is applicable to the BRICS countries. As rate of natural resource rents, renewable energy utilization, and coal rents show that a 1% increase in these non-renewable resources decreases ED by 4.38%, 9.21%, and 3.32%, respectively (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Sachs & Warner, 2001). Notably, renewable energy utilization has exacerbated

ED in the long run by 4%, indicating a complex relationship between resource utilization and development (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Sachs & Warner, 2001).

Conversely, fossil-fuel utilization and carbon emissions demonstrate a positive association with ED, indicating a potential for certain non-renewable resources to foster growth. A 1% increase in fossil-fuel utilization and carbon emissions leads to a considerable increase in ED by 22.1% and 34.1%, respectively (Cowan et al., 2014; Sachs & Warner, 2001). However, renewable energy utilization's adverse impact on ED in the long run, with a 5.19% decrease, showcases the intricate dynamics of resource dependencies and their implications on growth (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Sachs & Warner, 2001).

These findings align with the RCH, indicating that the extensive reliance on natural resources can adversely affect ED, possibly due to resource depletion or excessive dependence on these resources in most BRICS countries (Gylfason, 2001; Imran, Hayat, et al., 2022; Sachs & Warner, 2001). This illustrates the nuanced balance required in resource management to foster sustainable economic growth within these nations.

Table 6 presents the results of Common Correlated Mean Group, which is a robust estimator. The findings affirm the results derived by the CS-ARDL model with negative impact of rate of natural resource rents, renewable energy utilization, and coal rents on ED while having a same positive magnitude on ED in case of fossil-fuel utilization and carbon emissions (Ali et al., 2023; Cowan et al., 2014).

Such as overutilization of natural resources composed of rate of natural resource rents and coal rents confirm the existence of the RCH as both are having negative impacts on ED; whereas, the results of renewable energy utilization are again negative, indicating the misutilization of renewable sources which, although produce energy, negatively impacts ED (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Ullah et al., 2024).

Furthermore, the results of fossil-fuel utilization and carbon emissions prove the existence of the pollution heaven hypothesis, as the findings demonstrate that a rise in utilization of fossil-fuel utilization and increased CO_2 accelerate the ED in BRICS countries (Cowan et al., 2014; Sachs & Warner, 2001). This signifies the complex interplay between resource utilization, environmental factors, and economic growth, supporting the notions explored in the RCH literature.

6 | DISCUSSION

The previous section's findings suggest a number of associations between energy use and the BRICS economies. From 1980 until 2020, Brazil's energy industry grew steadily, as reported by Marco Mele (2019). Changes in the

TABLE 6 Common Correlated Mean Group estimator (Pesaran, 2006).

Variable	Coefficient
Rate of natural resource rents	−.0403310*** (0.0105110)
Renewable energy utilization	−.209910*** (0.0341500)
Coal rents	−.0293919*** (0.0178991)
Fossil fuel utilization	.304100*** (0.0094140)
Carbn dioxide emissions	.2050030*** (0.068130)
Constant	−.7011010*** (0.204011)

Note: Standard errors in parentheses ***p < .01, **p < .05, *p < .1.

country's energy policies across this time period have had varying impacts on energy consumption patterns (Clottey et al., 2018; Pao & Fu, 2013). In this study, a negative correlation was shown between rate of natural resource rents, coal rents, and ED both over the long and short terms, supporting the RCH (Otoo & Drechsel, 2021). This study's conclusions are supported by an analysis by Otoo and Drechsel (2021), who discovered that Brazil is the tenth most productive American continent in respect of fluid energy. Around 3.36 million barrels of oil were produced daily in the country in 2017. In the same year, Brazil also ranked seventh in global energy consumption. In 2017, petroleum made up 46% of Brazil's domestic consumption of energy; Wahab et al. (2022) have shown that the materials has a negative influence on ED, while carbon emissions and fossil-fuel utilization use have a beneficial impact (Cowan et al., 2014; Sachs & Warner, 2001).

China is using more and more energy every year, and its dependence on energy is increasing (Ali et al., 2022; Bakhsh et al., 2023; Zhang, Chen, et al., 2020). The mismatch between demand and supply of energy, as well as the disparity between the two, is rising. China's ED is being severely impacted by the rising cost of oil and coal, the two primary sources of energy (Fan & Hao, 2020a, 2020b; Zhang, Chen, et al., 2020; Zhou et al., 2020). While the benefits and possibilities of alternative energy are perfect for future development, creating and using alternative energy in a single day is challenging. The overall pattern of China's growth and the fossil-fuel utilization energy use system have contributed to growing emissions and ecological degradation, even as ED in the nation has accelerated in recent decades (Fan & Hao, 2020a, 2020b).

The energy structures of Russia and South Africa share some similarities, as both nations are rich in natural resources, particularly in coal and oil (World Energy Council, 2021a, 2021b; Dwumfour & Ntow-Gyamfi, 2017). Despite this, Russia has been investing heavily in renewable energy sources in recent years, particularly in wind and solar power, with plans to increase the share of renewables in the energy mix to 4.5% by 2024 and 20% by 2035 (International Renewable Energy Agency, 2020). In South Africa, coal accounts for the majority of primary energy consumption, followed by crude oil, natural gas, and renewable sources (IEA, 2019). The government has set a goal to increase renewable energy's share in the electricity mix to 30% by 2030 through a series of renewable energy procurement rounds (International Renewable Energy Agency, 2020). Although both countries are major emitters of greenhouse gases, Russia has committed to the Paris Agreement, while South Africa has pledged to peak its emissions by 2025 and begin reducing them thereafter (Department of Environment, Forestry and Fisheries, 2019; United Nations Framework Convention on Climate Change, 2021). Variations in energy supply and manufacturing methods may affect the transmission channels via which renewable energy affects the economies of these two nations in different ways (Chen et al., 2024; Wang et al., 2021 Zhuang et al., 2021).

Coal is utilized to fulfill the majority of the world's energy needs, but India relies on it more than any other country. Coal remains India's primary energy source despite recent shifts in the country's energy balance. The mining of coal in India is subject to some of the world's strictest regulations. As a major consumer, India pays a disproportionate share of its GDP on coal and rate of natural resource rents, which we find to be detrimental to ED in the BRICS countries (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Sachs & Warner, 2001). The use of both renewable and non-renewable energy sources has had a major effect on the ED procedure. Here, we show that the availability or abundance of resources is critical to maintaining ED, as does the resource curse theory (Dwumfour & Ntow-Gyamfi, 2018a, 2018b, 2018c; Sachs & Warner, 2001).

7 | CONCLUSION

The comprehensive analysis conducted on ED across the BRICS nations offers valuable insights into the intricate dynamics of resource utilization and its profound impacts on economic growth. The utilization of various econometric frameworks, spanning from 1991 through 2022, has provided a nuanced understanding of how different forms of resource exploitation intertwine with economic progress.

The validation of the RCH through the correlation between resource rent revenues, coal rent, and declining economic growth reaffirms the premise that an overemphasis on certain resources can impede economic advancement. This observation underscores the vulnerability of economies overly reliant on specific resources, highlighting the pitfalls of unchecked exploitation and over-reliance on singular resources, leading to economic stagnation in both the immediate and prolonged timelines.

Conversely, the unexpected adverse effects associated with increased renewable energy uptake challenge conventional assumptions. This revelation prompts a re-evaluation of preconceived notions regarding resource abundance, emphasizing the complexities inherent in resource utilization's impact on economic growth. It underscores the necessity of nuanced assessments to understand the diverse impacts of different resources on ED comprehensively.

Moreover, the positive associations found between fossil fuel usage, carbon dioxide emissions, and ED signal their potential contributions to fostering growth within these nations. This intricate relationship emphasizes the need for a holistic approach that accounts for environmental impacts while harnessing the potential of specific non-renewable resources to support sustained economic growth.

The implications of these findings extend beyond mere statistical correlation, emphasizing the criticality of balanced resource management strategies. The study underscores the necessity for diversified resource portfolios, pragmatic allocation policies, and the development of sustainable frameworks that mitigate the adverse consequences associated with an overreliance on specific resources.

In conclusion, the study's findings provide valuable insights into the nuanced relationship between resource utilization and ED. They serve as a clarion call for policymakers and stakeholders to adopt comprehensive and sustainable resource management strategies. These insights lay the groundwork for crafting policies that ensure balanced and judicious resource utilization, fostering resilient and sustainable economic growth within the diverse landscapes of the BRICS nations, mitigating the adverse impacts associated with resource abundance, and steering them toward long-term prosperity.

7.1 | Policy recommendations

Based on the outcomes discussed in the passage, the following policy recommendations can be made for all BRICS countries:

1. Brazil: (a) *Diversification for economic stability*: Given Brazil's reliance on agriculture and natural resources, diversifying its economy into technology, manufacturing, and service sectors could enhance economic stability. (b) *Sustainable Amazon preservation*: Implement policies for sustainable Amazon preservation, balancing resource utilization with conservation efforts to ensure long-term ecological and economic health.
2. Russia: (a) *Investment in innovation*: Encourage technological innovation to modernize industries and improve resource extraction efficiency, mitigating overreliance on fossil fuels. (b) *Diversification beyond oil and gas*: Strategically invest in alternative industries to diversify the economy beyond oil and gas, reducing vulnerability to global market fluctuations.
3. India: (a) *Renewable energy expansion*: Accelerate investment and deployment of renewable energy sources to mitigate reliance on fossil fuels, fostering sustainable energy practices. (b) *Technological advancement in agriculture*: Invest in innovative agricultural technologies to increase productivity, reducing dependence on traditional resource-intensive farming.
4. China: (a) *Green technologies and manufacturing*: Foster innovation in green technologies and sustainable manufacturing to reduce reliance on coal and mitigate environmental impacts. (b) *Efficient resource utilization*: Implement policies promoting efficient resource utilization, emphasizing recycling, and reducing waste in manufacturing and industrial sectors.

5. South Africa: (a) *Diversification into new sectors*: Encourage diversification into knowledge-based sectors such as technology and research to reduce dependency on mining resources. (b) *Sustainable mining practices*: Promote sustainable mining practices to balance resource extraction with conservation, safeguarding natural resources for the future.

These country-specific policy recommendations are tailored to each nation's unique socio-economic landscape, aiming to address the challenges highlighted by the study's findings. By aligning policies with ongoing situations and current resource utilization patterns, these recommendations strive to foster sustainable ED while mitigating the potential negative impacts associated with excessive resource dependence in each BRICS country.

AUTHOR CONTRIBUTIONS

MI: conceptualized, wrote methodology and conducted the econometric analysis, and analyzed the findings. MSA: conducted introduction and literature review. ZJ: conduct the econometric analysis and review the introduction and literature part. IZ: supervised, reviewed, and edited the whole manuscript. SW: review and edit the introduction literature part. MD: review and edit the methodology, result, and discussion and conclusion part.

CONFLICT OF INTEREST STATEMENT

The author declares no competing interests.

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