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Energy Transition, De-carbonization, and Capital Markets Nexus: Insights from BRICS Economies

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ABSTRACT

This study investigates whether the capital markets of BRICS economies promote or hinder energy transition and de-carbonization within these regions. Using Driscoll-Kraay standard errors, we analyze the annual data from 2000 to 2021. We use Fixed Effects and Random Effects Generalized Least Squares (GLS) methods to validate our empirical results. The findings indicate that private sector credit deepening and stock market development exacerbate carbon dioxide emissions, undermining the potential for decarbonization in BRICS economies. Additionally, non-renewable energy intensity and GDP growth are found to contribute significantly to pollution emissions, further impeding decarbonization efforts within this economic bloc. The results reveal that FDI and energy transition play a crucial role in advancing de-carbonization in BRICS countries. This study proposes practical policy implications to mitigate emissions and support sustainable economic growth in the BRICS economies.

Keywords: Energy Transition, Carbon Emission, Capital Markets, BRICS
JEL Classifications: O13, O16, Q43, Q43

1. INTRODUCTION

Decarbonization has become a crucial policy agenda for emerging economies due to their significant contributions to greenhouse gas emissions. These economies are responsible for a large portion of global emissions, primarily from sectors such as energy production, transportation, and manufacturing. Benita and Gaytán-Alfaro (2024) find that major industrial countries, due to their extensive burning of fossil fuel, emit a large share of CO_2 globally. Amidst this backdrop, capital markets of those countries are expected to play a critical role in reducing emissions by adopting environmentally friendly capital allocation policies. While these markets have significant potential to channel capital toward sustainable energy transitions, they often face structural and behavioral barriers that limit their effectiveness in supporting decarbonization efforts. Financial markets, including the banking sector and stock markets, promote carbon emissions by channeling substantial capital into carbon-intensive industries. Meanwhile, the COP28 UN Climate Change Conference in Dubai, the United Arab Emirates stresses the transition away from fossil fuels to promote decarbonization by reducing a significant amount of CO_2 emissions by 2030. In pursuit of harnessing this goal, the BRICS countries are gradually integrating sustainable practices into their economic frameworks by attracting more external capital and renewable energy consumption. Amidst this backdrop, we examine whether the financial markets of BRICS economies promote or hinder the decarbonization effort of the region, a significant question overlooked by existing literature. Additionally, we investigate to what extent foreign capital and energy transition contribute to decarbonization in the BRIC countries, a significant question overlooked by existing literature.

Our motivation for investigating the role of capital markets and energy transition in the decarbonization effort in the context of BRICS countries resonates from several theoretical and empirical stands. First, several studies document that capital markets, including the banking sector and stock markets, promote carbon emissions by channeling substantial capital into carbon-intensive industries (Kayani et al., 2023, Jiang and Ma, 2019; Ozturk and Acaravci, 2013; Zhang, 2011). Banks frequently provide loans and credit lines to fossil fuel companies for exploration, production, and infrastructure projects by overlooking long-term environmental costs (Dogan and Seker, 2016). Meanwhile, stock markets enable firms to raise funds through equity and bond offerings, attracting investors driven by the historically high returns associated with energy sectors (Zhang, 2011; Tian, 2018). Institutional investors and index funds often allocate significant portions of their portfolios to fossil fuel assets, reinforcing demand and incentivizing expansion (Jahnke, 2019). Additionally, The tendency of financial markets to prioritize short-term gains over long-term sustainability undermines the transition to cleaner technologies, as renewables are perceived as riskier or slower to generate returns (Nykvist and Maltais, 2022). This systemic bias toward fossil fuels perpetuates reliance on carbon-heavy energy systems, delaying critical decarbonization efforts. However, some studies argue that financial markets promote decarbonization by reducing carbon emissions. For example, Tao et al. (2023) find that in OECD countries, financial development significantly reduces the intensity of carbon emissions. They however find this negative nexus between finance-emission heterogeneous across the sample countries. Tamazian et al. (2009) state that financial development plays a key role in enabling listed companies to drive technological innovation and embrace new technologies in BRICS economies. This process enhances energy efficiency and supports the transition to a low-carbon economy, ultimately leading to a significant reduction in carbon emissions intensity. In another study, Luo and Tang (2021) point out those enterprises with stronger governance structures are generally more inclined to pursue low-carbon development strategies. As a result, financial development can improve enterprise performance; reduce energy consumption, and lower carbon emissions. The contrasting roles played by the financial markets with regard to reducing carbon emissions and promoting decarbonization lead us to explore this dynamic nexus in the context of BRICS nations.

Second, the impact of energy intensity on carbon emission has been given significant attention in the recent literature, revealing complex dynamics in the context of decarbonization. Energy intensity, i.e., energy use per unit of economic output, serves functions as a key factor for understanding how efficiently economies consume energy. Wang et al. (2019) emphasize that advancements in technology and structural economic changes play a crucial role in reducing energy intensity, making them significant factors in augmenting decarbonization in developed economies. However, this relationship is not always simple. Davis and Caldeira (2010) point out that decreases in domestic energy intensity are often accompanied by the outsourcing of emissions-intensive production to other countries, resulting in no aggregate reduction in global emissions. Besides, Liu and Bae (2018) find that rapid industrialization and urbanization in emerging economies like China have driven energy consumption and CO_2 emissions despite improvements in energy intensity. Yuping et al. (2021) show that in Argentina, high renewable energy penetration has successfully achieved simultaneous reductions in energy intensity and emissions, promoting decarbonization. However, the increased non-renewable energy use hinders the process of decarbonization in the country. Meanwhile, the relationship between economic growth and CO_2 emissions has been a focal point of extensive research. The recent acceleration in economic growth is largely attributed to factors such as industrialization, urbanization, and the development of transport infrastructure, all of which heavily rely on energy consumption from sources like oil and coal (Waheed et al., 2019). These resources are primarily utilized to produce electricity for industrial activities, power generation, and transportation. While increased energy consumption plays a crucial role in driving economic growth, industrialization, and urbanization, it also contributes significantly to carbon emissions (Wang et al., 2018). Grossman and Krueger (1991) suggested that during the early stages of economic development, CO_2 emissions generally increase due to the expansion of industrial activities and rising energy consumption. However, as economies reach a certain income threshold, emissions tend to stabilize or decline. This transition is often attributed to heightened environmental awareness and greater investment in cleaner and more efficient technologies. Stern (2004) states that this Environmental Kuznets Curve (EKC) hypothesis is evident in developed nations, where technological advancements and structural changes have facilitated the relative decoupling of economic growth from emissions. However, Liu and Bae (2018) argue that the EKC is not universally observed, particularly in emerging economies where rapid industrialization and urbanization drive sustained emissions growth despite increasing GDP. Jakob and Steckel (2014) state that economic inequality within developing nations can exacerbate environmental degradation, as the benefits of growth often fail to translate into investments in clean technologies or effective emissions control. Collectively, the literature indicates an inconclusive relationship between energy intensity, economic growth, and CO_2 emissions. Given this backdrop, we aim to investigate the impact of energy intensity and economic growth on the decarbonization scenario of the BRICS nations.

Third, the impact of foreign direct investment (FDI) on decarbonization and CO_2 emissions has been widely studied, with literature presenting mixed findings (see for example, Mahadevan and Sun, 2020; Zhu et al., 2016; Blanco et al., 2013). These findings are shaped by factors such as the host country's economic context, regulatory environment, and the sectoral allocation of FDI. One strand of research suggests that FDI can promote decarbonization by transferring advanced technologies and cleaner production methods from developed to developing countries, as documented (Emodi et al., 2023; Hamid et al., 2022). FDI often improves energy efficiency and reduces emissions intensity in host countries, particularly in industries that adopt international best practices (Hübler and Keller, 2010). Additionally, FDI in renewable energy sectors has been highlighted as a critical driver of low-carbon transitions in emerging economies (Pao and Tsai, 2011). However, studies like Zhu et al. (2016) argue that FDI can exacerbate emissions by fostering carbon-intensive industrial growth, particularly when investments target energy-intensive sectors or exploit lax environmental regulations in developing countries. Shahbaz et al. (2015) suggest that in some cases, FDI inflows contribute to increased CO_2 emissions in host nations, particularly where governance is weak, and environmental regulations are underdeveloped. Furthermore, Kaushal et al. (2024) state that the effect of FDI on emissions often depends on the source and destination of the investment; investments from countries with stringent environmental standards tend to have a more positive impact on decarbonization efforts compared to those from less regulated economies. Empirical studies also show variation across regions. For instance, Zhang and Zhou (2016) found that FDI contributed positively to energy efficiency and the reduction of carbon emissions in China, while Kivyiro and Arminen (2014) found that FDI significantly augments carbon emission in Sub-Saharan Africa due to the limited technological absorption capacity and the predominance of extractive industries of these economies. Fang et al. (2024) emphasize the role of green FDI-targeted investments in low-carbon technologies and sectors as a key determinant of whether FDI supports or hinders decarbonization. The present body of literature reveals a dynamic relationship between FDI and the decarbonization efforts of the nations. We therefore consider investigating to what extent FDI promotes decarbonization in BRICS economies, one of the major destinations of significant foreign capital.

Fourth, the present body of literature stresses the energy transition, i.e., the consumption of clean energy to improve the decarbonization scenario and reduce environmental damage. However, we find two strands of literature to argue on this. The first one is of the view that clean energy consumption can significantly and optimistically reduce carbon emissions (Aneja et al., 2024; Magazzino et al., 2022; Rahman and Alam, 2021), while the second strand opines that clean energy has a negligible impact on the reduction of carbon emissions or environmental sustainability (Xue et al., 2022). Specifically, in manufacturing and transportation industries, there is a greater usage of non-renewable resources, which leads to harmful waste generation and an increase in toxic pollutants emitted into the atmosphere. For instance, there is a possibility of oil leakages during marine transportation that disturb the marine ecosystem (Al Baroudi et al., 2021). In this case, the companies can use clean energy alternatives, which may affect the environment insignificantly. Several countries emphasize the increasing use of clean energy consumption as it aligns with the UN SDGs 2030. Amid these backdrops, the major drawback of renewable energy resources is their instability, as they are heavily impacted by weather conditions (Russo et al., 2022). We observe from the existing literature that renewable energy consumption and decarbonization, i.e.; reduction of carbon dioxide and greenhouse gas emissions have mixed nexus in the case of both advanced and emerging economies. We therefore intend to explore the impact of energy transition in augmenting decarbonization in the BRICS economies.

From the above motivational discourses, we find that the existing literature has extensively argued on the effects of financial markets and energy transition on decarbonization and came up with mixed outcomes. More precisely, the role of financial markets and energy transition in the context of emerging economies like BRICS has yet to receive a conclusive proposition. To bridge this gap, we aim to investigate the impact of financial markets and energy transition on the decarbonization effort of BRICS countries. Additionally, we investigate how energy efficiency, economic growth, and FDI contribute to the carbon emission scenario of the sample countries. We collect the annual data of these countries between 2000 and 2021 and apply the Driscoll-Kraay standard errors to analyze the panel data. We also employ both Fixed Effects and Random Effects Generalized Least Squares (GLS) methods to validate our empirical results.

Our empirical study indicates that private sector credit deepening and stock market development exacerbate carbon dioxide emissions, while simultaneously supporting long-term energy transitions, thereby hindering decarbonization efforts in BRICS economies. Moreover, non-renewable energy intensity and GDP growth significantly contribute to pollution, further obstructing progress toward a low-carbon future. However, the findings highlight that foreign direct investment (FDI) and energy transition are pivotal in advancing decarbonization within this economic bloc.

We bring novelty to our study from the following perspectives: First, to the best of our knowledge, we are the first to investigate the role of both credit market deepening and stock market development and energy transition in the context of BRIC economies. Second, we reveal a fresh insight that BRICS capital markets hinder the decarbonization effort in the regions by augmenting carbon emissions significantly. Third, we empirically prove that both indiscriminate uses of fossil energy and subsequent economic growth promote carbon emission significantly, limiting the prospect of decarbonization. Fourth, we propose that even though rampant capital markets, energy intensity, and economic growth promote carbon emission in the BRIC economies, energy transition and FDI inflow can play a tangible role in reducing this phenomenon and ensuring decarbonization.

The paper is organized in the following manner: Section 2 offers a comprehensive review of the existing literature and formulates the hypotheses of our research. Section 3 discusses the justification for choosing the variables, collecting data, specifying the econometric models, and selecting the research methodology. Section 4 presents the results obtained from our econometric investigations. In Section 5, we discuss the findings of our research in the light of existing literature. We provide the conclusion of our work and present several policies in section 6.

2. HYPOTHESIS DEVELOPMENT

We provide a comprehensive literature review to develop several hypotheses for investigating the impact of capital markets on the decarbonization effort of BRICS economies. The first sub-section discusses the role of capital markets (Banks credit and stock market development) in limiting decarbonization by augmenting carbon emissions. The second sub-section depicts the state of previous research on how energy use and economic growth promote carbon emission and hinder the decarbonization Process. In the third and fourth subsections, we discuss the role of FDI and energy transition in promoting decarbonization by reducing the carbon dioxide emission in the BRICS countries. Finally, we derive four different hypotheses from the aforementioned theoretical and empirical discourses.

2.1. The Role of Capital Markets in Decarbonization

The link between capital market deepening and economic growth has been a key focus of research over the past three decades, especially since the global financial crisis, with financial development seen as vital for driving innovation and growth (Sohag et al. 2024; Ullah et al., 2024, Ullah et al., 2025, Pradhan et al. 2016; Beck et al. 2014; Rajan & Zingales 1996). However, the influence of capital markets on environmental quality, especially carbon emissions, remains debated and theoretically ambiguous (Louche et al., 2019; Naqvi et al., 2023). On one hand, financial development can enhance environmental quality by supporting innovation, enabling investments in environmentally efficient technologies, reducing emissions, and promoting sustainability (Habiba et al., 2022; Baloch et al., 2021; Lv et al., 2021). On the other hand, financial development often coincides with increased energy consumption and economic expansion, as access to affordable credit allows households to acquire energy-intensive equipment and firms to expand using energy-demanding machinery, further exacerbating carbon emissions (Yang and Ni, 2022; Usman et al., 2021; Acheampong et al., 2020). Additionally, Sadorsky (2010) states that financial development drives risk diversification and economic growth, which, while beneficial, can heighten energy consumption and emissions. Several other empirical studies reveal inconclusive propositions regarding the nexus between finance and emission (see for example, Liu and Liu, 2021; Liu and Song, 2020; Omoke et al., 2020; Al-Mulali et al., 2015). These inconsistencies may arise from two primary factors, i.e., the lack of consideration for differing stages of financial development across countries and the dependence on single-dimensional indicators, such as domestic credit, stock market capitalization, or turnover, which can produce conflicting outcomes. Anu et al. (2023) state that advanced financial systems typically exhibit greater technological progress and credit access, suggesting that the impact of financial development on emissions is not uniform across economies. The contrasting propositions stress the need for further research into how financial development influences carbon emissions to augment the decarbonization effort of emerging countries like BRICS. Addressing these gaps, we consider investigating the impact of capital market deepening on the decarbonization effort of BRICS countries, particularly taking into account the reduction of CO_2 and greenhouse gas emissions. Accordingly, we develop the following hypothesis:

H_1: Capital markets influence decarbonization effort

2.2. The Effect of Energy Use and Economic Growth in Decarbonization

Economic growth and energy consumption are central to the environmental degradation debate, as both are linked to increased carbon emissions (Kayani et al., 2024, Škare and Porada-Rochoń, 2023; Zhao et al., 2023; Kayani et al., 2023; Ozturk, 2010). Policymakers face the challenge of balancing economic development with environmental sustainability, particularly as industrialization, urbanization, and transportation key drivers of economic growth depend heavily on energy sources like oil and coal. Both economic and population growth propel carbon emissions significantly, particularly in developing countries (Zhao et al., 2023). However, existing literature differs with regard to developing a link between energy consumption, economic growth, and carbon emission (Nawaz et al., 2024). For example, (Kraft and Kraft, 1978) used the Granger causality test to explore the relationship between energy consumption and economic growth across countries. He argued that energy conservation policy should not be an acceptable policy as it might reduce the gross national product. Ozturk (2010) also confirmed the similar relationship between energy consumption and economic growth. Fan et al. (2023) state that urbanization drives changes in total energy consumption and its structure, with fossil fuel combustion as the primary source of carbon emissions, linking urbanization closely to energy use and carbon emissions. Cai et al. (2021) also claim that Cities account for more than 70% of global carbon emissions, making them pivotal contributors to climate change. Urban carbon emissions are likely to rise further, particularly in less-developed countries and regions experiencing rapid urbanization. Hu and Man (2023) state that industrial processes consume significant energy and emit considerable carbon dioxide. They conclude that accurate forecasting of energy consumption and carbon emissions can help industries achieve cleaner production, optimize energy use, lower costs, and reduce emissions through better production control. Sarwar et al. (2017) find a bidirectional relationship between electricity consumption and GDP. Further, finding further shows that in countries relying on non-renewable sources like coal and oil for electricity generation, electricity consumption shows a negative correlation with economic growth. However, these findings differ based on income levels, OECD membership, regional differences, and the extent of renewable energy consumption. The present body of literature gives contradictory verdicts on the role of energy consumption and economic growth with regard to the decarbonization efforts of the countries. Considering this scenario, we intend to study this nexus from the BRICS perspective under the following hypothesis:

H_2: Energy consumption and economic growth hinder decarbonization effort

2.3. The Role of FDI in Promoting Decarbonization

Existing studies extensively discuss the dynamic nexus between FDI inflow and carbon emissions, yielding diverse findings (see for example, Luo et al., 2022; Kayani et al., 2022, Song et al., 2021; Yi et al., 2023). These studies primarily focus on three perspectives: the pollution haven hypothesis, the pollution halo hypothesis, and non-linear or heterogeneous effects. The pollution haven hypothesis argues that FDI inflows increase carbon emissions in host countries (Apergis et al., 2023). Multinational corporations from developed countries often invest in regions with less stringent environmental regulations to maximize profits, transferring polluting industries to these areas (Rondinelli and Berry, 2000). This results in higher emissions alongside FDI-driven economic growth. (Grimes and Kentor, 2003) find that FDI inflows significantly increase carbon emissions in the developing countries. Mahadevan and Sun (2020) find that FDI-led industrial expansion functions as a key driver of environmental degradation. Saqib and Dincă (2024) argue that developing countries frequently adopt flexible environmental policies to attract foreign investment, which intensifies carbon emissions in these countries. However, Campos-Romero et al. (2024) argue that such strategies are deliberate choices by host governments to stimulate growth. Supporting this proposition, Muhammad and Long (2021) find that countries with high corruption, and multinational corporations influence governments to relax environmental regulations and experience massive increases in carbon emissions. However, the pollution halo hypothesis proposes that FDI inflows can reduce carbon emissions by introducing cleaner and more efficient technologies. For example, Melane-Lavado et al. (2018) find that FDI is primarily attracted by technology supply. When FDI is combined with medium-sized enterprises in the medium-high technology manufacturing sector, it reveals positive spillovers. However, these spillovers largely depend on public financing, which enhances the companies' innovation and sustainability practices. Zhu et al. (2016) observed that in South Asian countries, FDI negatively affects carbon emissions mostly at the higher quantiles. Meanwhile, a third perspective highlights the heterogeneity and non-linear nature of the FDI-carbon emissions relationship. For instance, Alshubiri and Elheddad (2020) found a non-linear relationship in 32 OECD countries, where FDI initially correlates positively with emissions but later reduces them beyond a threshold. Besides, Shahbaz et al. (2015) argue that the FDI-emission nexus depends on income levels. They find an inverted U-shape relationship in this context in middle-income countries. They conclude that high-income nations manage to mitigate emissions through FDI but the scenario is the opposite for low-income nations. We reveal from the existing literature that FDI has both positive and negative roles in the context of the Decarbonization effort. This debated outcome leads us to develop the following hypothesis for exploring the impact of FDI on Decarbonization in BRICS countries.

H_3: FDI promotes Decarbonization in BRICs countries**.**

2.4. The Role of Energy Transition in Augmenting Decarbonization

Energy transition is critical to reducing greenhouse gas (GHG) emissions and promoting decarbonization by replacing fossil fuel-based systems with low-carbon alternatives (Kayani et al., 2021; Kacprzyk and Kuchta, 2020; Rathnayaka et al., 2018; Sinha and Bhattacharya, 2017). (Sharif et al., 2021) propose that the growing reliance on fossil-based energy and its contribution to global warming necessitate a transition to renewable energy solutions. Rahman et al. (2022) state that renewable energy sources such as solar, wind, hydropower, biomass, and geothermal significantly mitigate emissions by displacing fossil fuels in power generation, transportation, and industrial processes, with potential reductions of up to 70% in energy sector emissions by 2050. The energy transition enhances environmental sustainability by improving air quality, conserving water, reducing ecosystem degradation, and supporting circular economy principles (Mutezo and Mulopo, 2021). Considering the critical roles of GDP and energy consumption in driving carbon emissions, scholars emphasize the need to analyze the distinct influences of renewable and non-renewable resources (Bilgili et al., 2016; Cerdeira Bento and Moutinho, 2016). Evidence suggests that incorporating renewable resources in the energy mix effectively reduces carbon emissions (Mehdi and Slim, 2017). Alola and Joshua (2020) find that green energy reduces carbon emissions in high-income, upper-middle-income countries, and low-income countries. However, they find that fossil energy consumption worsens environmental conditions across countries with all income levels. Valentine et al. (2019) state that from a global point of view, transitioning from fossil fuels to renewable energy offers a solution to the dual challenge of reducing greenhouse gas (GHG) emissions to mitigate climate change while ensuring access to clean, affordable energy amidst anthropogenic environmental changes and rapid global economic growth. Lederer et al. (2018) state that the international community considers low-carbon transitions, including energy shifts, as a transformative process aimed at achieving multiple objectives simultaneously: fostering a green economy, expanding access to renewable energy, alleviating poverty, creating decent employment opportunities, safeguarding the environment, and addressing climate change. Accordingly, Khan et al. (2022) examine clean energy transitions and fossil fuel usage in 31 countries and find that fossil energy increases the ecological footprint, while clean energy transitions significantly reduce it. Besides, Koengkan and Fuinhas (2020) confirmed the negative effect of clean energy transitions on carbon emissions in the Caribbean and Latin America. In another study conducted on 20 countries, Khan et al. (2022) demonstrated that energy trilemma (security, sustainability, and affordability) has a positive impact on income growth and ecological balance in those countries. On the other hand, Onifade et al. (2021) found no existence of the Environmental Kuznets Curve with regard to energy transition in the OPEC countries. They, however, show a negative impact of green energy on emissions. In another study, Ren et al. (2021) explored energy transitions and pollution in the EU nations showing that economic growth exacerbates pollution, while clean energy's spatial effects on emissions were insignificant. Qazi et al. (2019) claimed that internationally binding agreements, such as the Kyoto Protocol, facilitate the transition to cleaner energy sources, including renewable and nuclear energy, by imposing carbon reduction targets in production processes. We observe from the extant literature that energy transition functions as a crucial determinant for decarbonization in both developed and developing countries. However, very few of the existing literature investigated the dynamic of energy transition in the context of the decarbonization effort of the BRICS nations. We therefore consider exploring this gap under the following hypothesis:

H_4: Energy transition reduces carbon emissions and promotes decarbonization.

3. MODEL SPECIFICATION AND RESEARCH METHODOLOGY

3.1. Data

We investigate the impact of capital market deepening and energy transition on the decarbonization effort of the BRIC economies. By following Cha and Pastor (2022), Psaraftis and Kontovas (2020), Sovacool et al. (2019) Ouikhalfan et al. (2022), and Nagaj et al. (2024), we consider a decrease in the total amount of Carbon di

Oxide (CO_2) emission and total greenhouse gas emissions per capita as the proxies for promoting decarbonization. We consider that increases in CO_2 and total greenhouse gas emissions per capita are hindrances to the decarbonization effort. For the proxy of capital market deepening, scholars considered both private credit market and stock market indicators. For example, in the context of private credit market deepening, Sadorsky (2010) considered multiple measures that comprised of deposit to GDP ratio, private credit provided by banks to GDP ratio, etc. However, Al Mamun et al. (2018) propose that deposits are closely linked to a bank's aggregate assets as large banks typically have a relatively higher volume of deposits. Besides, bank deposits greatly represent the loan extended to the private sector (Fe and Kouton, 2022). Therefore, we consider the domestic credit granted to the private sector as our only proxy for credit deepening. We follow the works of Osamwonyi and Kasimu (2013), Owusu and Odhiambo (2014), and Levine and Zervos (1996) to consider the total value of stocks traded as the proxy of Stock Market development. We consider using renewable energy consumption (percentage of total energy consumption) as the proxy for Energy Transition by following the examples of Aneja et al. (2024), Shahbaz et al. (2022), and Magazzino et al. (2022). We also consider several control variables to examine our research hypotheses from several macroeconomic aspects. For example, by following Sohag et al. (2024), Shakib et al. (2023), and Cherodian and Thirlwall (2015), we consider the Log of GDP per capita as the proxy of economic growth. For denoting energy intensity, we consider energy use (kg of oil equivalent per capita) by following the works of Kakizhanova et al. (2024), Ozturk and Acaravci (2010), and Sohag et al. (2015). Log of Gross fixed capital formation (current US$) Log of Foreign Direct Investment, net inflows (BoP, current US$). We collect data on these variables for five BRICS countries, Brazil, Russia, India, China, and South Africa from the World Development Indicators (WDI) database for the period from 2000 to 2021. A detailed explanation of all the variables and sources of data collection is stated in Table 1.

3.2. Model Specification and Research Methods

We operationalize our research hypotheses with regard to the dynamics of the energy transition, decarbonization, and the Capital Markets of BRICS economies by developing the following econometric framework:

$$DCARB=f\,(CRDT, STK, LGFCF, LFDI, LGDPPC, EI, ET) \quad (1)$$

By applying the traditional regression method, we model Eq. (2) and Equation (3) as follows:

$$CO2_{i,t} = \alpha + \beta_1\, CRDT_{i,t} + \beta_2\, STK_{i,t} + \beta_3\, LGFCF_{i,t} + \beta_4\, LFDI_{i,t} + \beta_5\, LGDPPC_{i,t} + \beta_6\, EI_{i,t} + \beta_7\, ET_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$GHGE_{i,t} = \alpha + \beta_1\, CRDT_{i,t} + \beta_2\, STK_{i,t} + \beta_3\, LGFCF_{i,t} + \beta_4\, LFDI_{i,t} + \beta_5\, LGPPC_{i,t} + \beta_6\, EI_{i,t} + \beta_7\, ET_{i,t} + \varepsilon_{i,t} \quad (3)$$

Where, CO_2 (Carbon die Oxide Emission) and GHGE (Green House Gas Emission) are the proxy for our dependent variable, decarbonization. With regard to independent variables, CRDT refers to credit market development and STK refers to stock market development. Besides, the control variable LGFCS refers to the log of Gross Fixed Capital Formation, LFDI refers to the log of Foreign Direct Investment, LGDPPC refers to economic growth, EI refers to energy intensity and ET refers to the renewable energy transition. Moreover, i refers to number of cross sections and for and "t" refers to time. Additionally, α stands for the intercept, and β for the parameters. Finally, $\varepsilon_{i,t}$ refers to the disturbance term.

3.2.1. Cross-sectional dependence (CD) tests

We begin our empirical analysis by examining the interconnections among cross-sectional units. Factors such as economic integration and globalization significantly influence the dependence observed in the panel data. Ignoring cross-sectional dependence in panel data estimations, as some prior studies have done, can lead to inconsistent results due to the entanglement of interdependence within the data. To address this issue, Breusch and Pagan (1980) developed the Lagrange Multiplier (LM) test statistic, which is used to determine the presence of cross-sectional dependence. The equation presented below defines the calculation of the LM statistic:

$$LM = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}^{2} \quad (4)$$

Table 1: Variables, definitions, and source

	Indicator/Variable use in this Study	License URL
DCARB	Carbon dioxide (CO_2) emissions excluding LULUCF per capita (t CO_2e/capita)	https://databank.worldbank.org/source/world-development-indicators
	Total greenhouse gas emissions per capita excluding LULUCF (t CO_2e/capita)	https://databank.worldbank.org/source/world-development-indicators
CRDT	Domestic credit to private sector (% of GDP)	https://databank.worldbank.org/source/world-development-indicators
STK	Stocks traded, total value (current US$)	https://databank.worldbank.org/source/world-development-indicators
LGFCF	Log of Gross fixed capital formation (current US$)	https://databank.worldbank.org/source/world-development-indicators
LFDI	Log of Foreign direct investment, net inflows (BoP, current US$)	https://databank.worldbank.org/source/world-development-indicators
LGDPPC	Log of GDP per capita (current US$)	https://databank.worldbank.org/source/world-development-indicators
EI	Energy use (kg of oil equivalent per capita)	https://databank.worldbank.org/source/world-development-indicators
ET	Energy Transition (Renewable energy consumption % of total final energy consumption)	https://databank.worldbank.org/source/world-development-indicators

where T refers to time, N refers to total cross-sections, and $\hat{\rho}_{ij}^2$ represents the sample correlation between residuals for two variables, calculated using a simple Ordinary Least Squares (OLS) regression equation. A key limitation of the LM test statistic is that it is most appropriate for scenarios with a large T and a relatively small N. To address this limitation, Pesaran (2004) introduced a modified Lagrange Multiplier statistic to perform the CD test, as outlined below:

$$CD_{lm} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(T\hat{\rho}_{ij}^2 - 1\right) \tag{5}$$

The null hypothesis for both tests assumes that the cross-sectional entities are independent, while the alternative hypothesis suggests the presence of dependence among them.

3.2.2. Slope homogeneity tests

After assessing cross-sectional dependence, the next step involves testing the homogeneity of slope coefficients using the slope homogeneity test proposed by Pesaran and Yamagata (2008). However, in heterogeneous panels, slope homogeneity may lead to unreliable estimations (Ahakwa et al., 2023). Furthermore, Bedir and Yilmaz (2016) state that earlier methods for testing homogeneity often overlooked country-specific characteristics. To address these limitations, Pesaran and Yamagata (2008), building on the work of Swamy (1970), introduced a standardized dispersion test statistic denoted as $\tilde{\Delta}$ for evaluating slope homogeneity. The test statistic is defined as follows:

$$\tilde{\Delta} = \sqrt{N}\left(\frac{N^{-1}\underline{S} - k}{\sqrt{2k}}\right) \sim \frac{X^2}{k} \tag{6}$$

where the test of Swamy (1970), is represented by $\underline{S}$. For the small sample, the modified $\tilde{\varnothing}$ to $\tilde{\varnothing}_{adj}$ may be presented in the following manner:

$$\tilde{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}\underline{S} - k}{\sqrt{v}(T,k)}\right) \sim N(0,1) \tag{7}$$

Where N represents the number of cross section and S represents the values derived from the test of Swamy P.A.V.B. (1970). k denotes the independent variables. If the P < 5%, the null hypothesis is rejected at the 5% significance level, indicating that the co-integrating coefficients of the test statistics are heterogeneous. The $\tilde{\varnothing}$ and $\tilde{\varnothing}_{adj}$ tests are suitable for both large and small panels, respectively. The $\tilde{\varnothing}_{adj}$ test is an adjusted version of $\tilde{\varnothing}$, incorporating a "mean-variance bias adjusted" parameter, where v represents the adjustment variance. It is important to note that the standard $\tilde{\Delta}$ test assumes the absence of autocorrelation.

3.2.3. Panel unit root tests

To prevent spurious results, we assess the stationarity of the panel data and utilize the second-generation panel unit root test, known as the Cross-sectional Im, Pesaran, and Shin (CIPS) test, developed by Im et al. (2003). The CIPS test is designed to account for cross-sectional dependence and the effects of common correlation. The cross-sectional regression for the CIPS test is represented by the following equation:

$$\Delta Y_{it} = \alpha_i + b_i Y_{i,t-1} + c_i \underline{Y}_{t-1} + c_i \Delta\underline{Y}_t + \omega_{it} \tag{8}$$

Where Δ represents the change dynamics, Y refers to the dependent variable, $\underline{Y}_t$ and $\underline{\varnothing Y}_t$ denote the $\frac{1}{N}\sum_{i=1}^{N} biY_{it}$ and $\frac{1}{N}\sum_{i=1}^{N} ci\Delta Y_{it}$, respectively, and ω_{it} denotes the error term.

3.2.4. Driscoll-kraay standard errors

We apply the Driscoll and Kraay (DK) estimator proposed by Driscoll and Kraay (1998) due to its robustness in addressing various econometric challenges inherent in panel data. We primarily consider using the DK estimator because it can mitigate the issue of cross-sectional dependence in the panel data. Besides, existing studies highlight several advantages of the DK estimator. For example, Driscoll and Kraay (1998) claim that this method provides efficient and consistent coefficient estimates even under conditions of autocorrelation and heteroscedasticity. Additionally, this approach accommodates both balanced and unbalanced panels and is robust to the presence of missing values. Besides, Sheraz et al. (2021) the estimator effectively addresses both the general form of cross-sectional dependence (CD) and temporal dependence. The DK standard errors are particularly resilient in datasets with a large time dimension (T), maintaining robustness under extremely general forms of cross-sectional (spatial) and temporal dependency. This nonparametric approach for standard error calculation imposes no restrictions on the asymptotic behavior of the number of panels (N) relative to the time dimension (T). As a result, the DK estimator remains practical and effective even in cases where N is substantially larger than T, making it suitable for datasets with a wide cross-sectional dimension. One of the most notable advantages of the Driscoll-Kraay methodology is its ability to adjust standard errors in the presence of cross-sectional dependence. This feature ensures that the results are reliable and robust, addressing a critical limitation in conventional estimation methods. Hence, the DK estimator provides a flexible and robust tool for analyzing panel data in the presence of complex dependencies. The DK estimator can be expressed with the following equation:

$$y_{i,t} = \alpha_0 + X_{it}^* + \varepsilon_{i,t} \tag{9}$$

Where, y refers to the dependent variable, X refers to the independent variables, i is the number of cross-sections, t is the time and ε is the error term.

3.2.5. The fixed effect OLS method

We employ Pesaran's (2004) FE-OLS approach, which incorporates individual intercepts and accounts for heterogeneous serial correlation across panel data. Typically, panel data estimation involves either a fixed-effects or a random-effects model. The random-effects model is better suited for capturing unobserved heterogeneity across cross-sections when certain variables remain constant over time but vary across cross-sections (Sheraz et al., 2021). It is generally appropriate for cases with a large number of cross-sections (N) that are randomly sampled. In contrast, the fixed-effects model is designed to control for omitted variable bias by holding cross-sectional heterogeneity constant over time, making it suitable for scenarios with a small number of cross-sections (Arellano, 2003). Our study includes five cross-sections (N = 5), six explanatory variables (k = 6), and twenty-one observations (T = 21). Based on the structure of our data, where the number of cross-sections is smaller than the number of observations (N < T), and in line with prior research of Akram et al. (2021) we consider applying the FE-OLS approach.

4. ANALYSIS OF RESULTS

4.1. Descriptive Statistics

We begin our empirical investigation by measuring the descriptive statistics of the dataset. Table 2 contains the descriptive statistics for all variables. It takes into account the data for five BRICS nations ranging from 2000 to 2021. To overcome the problem of heteroscedasticity and linearity during the sampling time, these variables were changed into natural log values. The table compares the overall, between, and within standard deviations of the variables. It highlights the significant variability between entities compared to within-entity variation, particularly for variables like CO_2 and GHGE. We consider applying Driscoll and Kraay method appropriate here as it accounts for cross-sectional dependence, which is likely given the substantial between-entity variation relative to within-entity variation in many variables.

4.2. Correlation Analysis

The correlation matrix concerning the variables is displayed in Table 3. It shows a positive and statistically significant correlation between Carbon dioxide and greenhouse gas emissions, Private Credit, and Stock Market trade, denoting that Capital markets promote carbon emission, which eventually hinders the decarbonization process in the BRICS countries. The statistics further confirm a strong correlation between energy intensity, GDP growth, and carbon emissions proving that both energy intensity and economic growth deteriorate the decarbonization effort of the cross sections. However, the correlation matrix confirms that both FDI and the transition to renewable energy significantly augment decarbonization in BRICS. Though the correlation statistics give us a clear insight, it is not sufficient to establish any proposition. That is why this study undertakes a series of estimations to validate the conceived propositions.

4.3. Cross-sectional Dependence, Slope Homogeneity, and Unit Root Test

By following Pesaran's (2004), we perform the cross-sectional dependence (CSD) test for our variables. Pesaran (2004) claims that CSD tests handle any potential bias regarding the regression outcomes. We also perform the second-generation panel unit root test, known as the Cross-sectional Im, Pesaran, and Shin (CIPS) test, developed by Im et al. (2003) to prevent spurious results The CIPS test is designed to account for cross-sectional dependence and the effects of common correlation. Table 4 presents the

Table 2: Descriptive statistics

Variable	Mean	Standard Deviation	Min.	Max.	Observations
CO_2					
Overall	6.084752	4.09184	0.93773	13.35225	N=110
Between		4.427382	1.407519	12.09158	n=5
Within		0.958081	2.600674	8.706579	T=22
GHGE					
Overall	8.59419	4.736162	1.795403	18.0027	N=110
Between		5.126369	2.268325	15.88963	n=5
Within		1.102099	4.715018	11.49058	T=22
DCPS					
Overall	77.86932	43.27105	16.83777	182.8681	N=110
Between		45.03359	40.39642	133.4721	n=5
Within		15.3323	46.4008	127.2653	T=22
STK					
Overall	27.0166	1.584856	24.06265	31.32886	N=110
Between		1.313464	25.88628	29.12711	n=5
Within		1.057807	24.43641	29.21835	T=22
LGFCF					
Overall	26.44152	1.39691	23.61959	29.64271	N=110
Between		1.355298	24.64742	28.41187	n=5
Within		0.684405	24.73084	27.67235	T=22
LFDI					
Overall	23.93364	1.502219	20.25053	26.56413	N=110
Between		1.361791	21.97865	25.72767	n=5
Within		0.871478	21.9296	26.38347	T=22
LGDPPPC					
Overall	8.480366	0.758759	6.627356	9.325743	N=110
Between		0.78004	7.128092	9.023216	n=5
Within		0.290655	7.579392	9.211701	T=22
ENU					
Overall	2120.896	1477.828	414.4834	5160.642	N=75
Between		1614.452	500.2246	4671.542	n=5
Within		265.7698	1432.713	2758.081	T=15
REC					
Overall	2.737118	0.968053	1.163151	3.912023	N=110
Between		1.059289	1.226481	3.813373	n=5
Within		0.176677	2.41669	3.379661	T=22

Table 3: Correlation matrix

Variable	CO_2	GHGE	DCPS	STK	LGFCF	LFDI	LGDPPPC	ENU	REC
CO_2	1								
GHGE	0.9759	1							
	0								
DCPS	0.2244	0.13	1						
	0.0184	0.1758							
STK	−0.143	−0.2053	0.4725	1					
	0.1361	0.0315	0						
LGFCF	−0.1266	−0.1685	0.2704	0.8857	1				
	0.1875	0.0784	0.0043	0					
LFDI	−0.156	−0.1373	0.1438	0.7676	0.8793	1			
	0.1037	0.1526	0.134	0	0				
LGDPPPC	0.5991	0.7218	0.2458	0.0222	0.0148	0.1822	1		
	0	0	0.0096	0.818	0.8784	0.0567			
ENU	0.9618	0.981	−0.0537	−0.2204	−0.2113	−0.0873	0.643	1	
	0	0	0.6473	0.0574	0.0688	0.4564	0		
REC	−0.9783	−0.9384	−0.1323	0.1944	0.1506	0.191	−0.483	−0.9531	1
	0	0	0.1681	0.0419	0.1163	0.0456	0	0	

Table 4: Cross-sectional dependency and unit root test (CIPS)

Variable	CD	abs (corr)	Order of Integration	
			Level	1st Difference
CO_2	6.05***	0.431	−1.374	−2.772***
GHGE	7.00***	0.549	−1.248	−2.819***
DCPS	6.89***	0.606	−1.325	−3.494***
STK	10.60***	0.876	−1.972	−4.193***
LGFCF	11.60***	0.960	−1.816	−4.064***
LFDI	8.42***	0.697	−2.603***	−5.414***
LGDPPPC	11.73***	0.971	−1.901	−3.001***
ENU	9.73***	0.806	−1.523	−2.482**
REC	4.92***	0.485	−2.342**	−3.193***

***Significance at the 1% level. **Significance at the 5% level. *Significance at the 10% level

Table 5: Homogeneity test

Estimation	Delta	P-value
	−6.66e+04	0
adj.	−2.84e+04	0

Ho: Slopes are homogenous
Source: Author's calculation

results of the CSD test and unit root tests. Column 2 shows the existence of a cross-sectional dependency and column 3 presents the existence of a mixed order of integration in the panel. After assessing cross-sectional dependence, we test the homogeneity of slope coefficients using the slope homogeneity test proposed by Pesaran and Yamagata (2008) to avoid unreliable estimations we find the $P < 5\%$, indicating the null hypothesis is rejected at the 5% significance level. This confirms that the co-integrating coefficients of the test statistics are heterogeneous.

4.4. Driscoll-Kraay Standard Errors Test Results

Table 6 illustrates the regression results of the Driscoll-Kraay standard errors approach for the panel data that deals with the issue of temporal and cross-sectional dependence. The findings confirm that a 1% increase in the domestic credit provided to the private sector and stock market trade increased CO_2 by 0.01178% and 0.22420, respectively. Both the measures of capital market deepening are significant at a 1% level. Thus, overall results indicate that capital market deepening significantly augments carbon dioxide emission, hindering the progress of decarbonization in BRICS countries. Besides, we report from Table 5 that both energy intensity and economic growth significantly augment carbon emissions in BRICS countries. Such a positive nexus reveals that the non-renewable energy-intensive production process dominates the economic growth trajectory of the BRICS regions. However, our results deliver promising insights in relation to the nexus among energy transition, FDI, and decarbonization. We report that both renewable energy consumption and FDI inflow significantly reduce carbon emissions in BRICS countries. Such negative relationship dynamics reveal that BRICS countries benefit from FDI both economically and environmentally. Besides, this nexus claims that renewable energy transition become phenomenal in the context of contemporary decarbonization drives in these regions.

Meanwhile, we form our second econometric model to assess the impact of capital markets on greenhouse gas emissions in BRICS economies. The objective is to further explore the decarbonization and capital market dynamics in these countries from the entire emission point of view. In Table 6, we present the estimation results of that model and we reveal identical results to our main econometric model specification. The empirical outcomes of the second model signify the results obtained through our main model.

4.5. Results of Fixed Effects and Random Effects

The fixed effects model assumes that each country has its intercept (fixed effect) that varies across cross-sectional units. The results of fixed effects estimation are reported in Table 7. Like our findings with the Driscoll Karry estimation, the fixed effect estimation depicts that a 1% increase in the domestic credit provided to the private sector and total stock market increase CO_2 by 0.00553% and 0.17371%, respectively. We also observe from the fixed effect model that both energy intensity and economic growth significantly deter the decarbonization process by contributing to emission production in BRICS countries. However, following the main estimation model, our fixed effect-based outcome reports that energy transition and FDI inflow significantly promote decarbonization in BRICS regions. Finally, we analyze our panel

Table 6: The main estimation results

Model 1 (CO_2 emission)						
	Driscoll and Kraay's standard error		Fixed-effects		Random-effects GLS	
Variables	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
DCPS	0.01178***	0.0000	0.0078	0.0240	0.01178***	0.0000
STK	0.22420***	0.0000	0.2022	0.0000	0.22420***	0.0000
LGFCF	(0.25077)***	0.0260	-0.9463	0.0000	(0.25077)***	0.0040
FDI	(0.12679)**	0.0850	-0.0595	0.1390	(0.12679)***	0.0380
LGDPPPC	0.26121***	0.0030	1.5270	0.0000	0.26121***	0.0040
ENU	0.00111***	0.0000	0.0024	0.0000	0.00111***	0.0000
REC	(2.37553)***	0.0000	-1.5972	0.0000	(2.37553)***	0.0000
Constant	10.69430***	0.0000	12.7939	0.0000	10.69430***	0.0000
Observation	75		75		75	
R^2	0.9960		0.9364		0.9960	
F-statistic/Wald χ^2	28476.49		270.27		16740.04	
Prob. F-statistic/Prob. χ^2	0.0000		0.0000		0.0000	
Groups			5		5	

***Significance at the 1% level. **Significance at the 5% level. *Significance at the 10% level

Table 7: The main estimation results

Model 2 (Green house gas emission)						
	Driscoll and Kraay's standard error		Fixed-effects		Random-effects GLS	
Variable	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
DCPS	0.00554***	0.0000	0.00680***	0.0430	0.00553***	0.0000
STK	0.17371***	0.0010	0.19808***	0.0000	0.17371***	0.0000
LGFCF	(0.28275)***	0.0000	(0.86331)***	0.0000	(0.28275)***	0.0000
FDI	(0.13050)***	0.0200	(0.08942)***	0.0240	(0.13050)***	0.0110
LGDPPPC	1.36010***	0.0000	1.58614***	0.0000	1.36010***	0.0000
ENU	0.00168***	0.0000	0.00293***	0.0000	0.00168***	0.0000
REC	(1.51904)***	0.0000	(1.25194)***	0.0000	(1.51904)***	0.0000
Constant	3.04007**	0.0710	11.30807***	0.0000	3.04007***	0.0010
Observation	75		75		75	
R^2	0.9979		0.9883		0.9979	
F-statistic/Wald χ^2	76525.95		366.83		31582.34	
Prob. F-statistic/Prob. χ^2	0.0000		0.0000		0.0000	
Groups	5		5		5	

***Significance at the 1% level. **Significance at the 5% level. *Significance at the 10% level.

data with the random effects model, which assumes that error terms (random effects) vary across cross-sectional units. The results of random effects estimation are reported in Table 6 and the findings confirm both the Driscoll Karry estimation and the Fixed Effect model. However, after executing the Hausman Test, we consider accepting the results obtained through the Fixed Effect Model for validating the results of our main estimation technique.

Meanwhile, we empirically analyze our second econometric model (taking greenhouse gas emission as a proxy) with both Fixed and Random Effect Models to see the robustness of our main results. In Table 7, we present the estimation results of both Fixed and Random Effect models and reveal similar results to our main econometric model specification. The empirical outcomes of the second model further signify the results obtained through our main model, which proposes that capital markets hinder the progress of decarbonization in BRICS countries by augmenting carbon emissions.

5. DISCUSSION

We examine the impact of capital markets on energy transition and decarbonization in BRICS economies. We find that both private sector credit deepening and stock market development simultaneously augment carbon dioxide emissions, undermining the progress of decarbonization of BRICS countries. We further find that non-renewable energy intensity and GDP growth significantly contribute to pollution emissions, further hindering progress toward decarbonization. However, we find that FDI and renewable energy transition augment decarbonization in the sample countries by significantly reducing carbon emissions.

The findings of our empirical investigation converge with and diverge from a few existing literature. For example, the outcome of our hypothesis that capital markets significantly contribute to carbon emission and limit the decarbonization process coincides with the studies of Nykvist and Maltais (2022), Jahnke (2019), Tian (2018), Dogan and Seker (2016), Zhang (2011).

Yang and Ni (2022), Usman et al. (2021), and Acheampong et al. (2020) argue that financial market development promotes energy consumption and economic growth, as access to affordable capital allows households and businesses to acquire energy-intensive equipment and machinery, promoting decarbonization. However, Our result diverges with Habiba et al. (2022), Baloch et al. (2021), and Lv et al. (2021) who argue that financial markets promote innovation and clean technology-based production processes, which eventually contribute to decarbonization efforts of countries. Besides, our finding in relation to the nexus among energy intensity, economic growth and decarbonization goes in line with the claims of Škare and Porada-Rochoń (2023), Zhao et al. (2023), Zhao et al. (2023), Ozturk (2010), Fan et al. (2023), and Jakob and Steckel (2014) who find that energy intensity and economic growth promote carbon emission and limit decarbonization. They conclude that energy intensity stemming from rapid industrialization, energy intensive production process, population, and economic growth contribute to increased carbon emission, particularly in developing and low-income countries. However, our finding does not follow the studies of Sarwar et al. (2017) who find that in countries relying on non-renewable sources like coal and oil for electricity generation, electricity consumption shows a negative correlation with economic growth. Meanwhile, our empirical finding on the impact of FDI on decarbonization correlates with the findings of Emodi et al. (2023), Hamid et al. (2022), Melane-Lavado et al. (2018), Zhu et al. (2016), and Hübler and Keller (2010) who find that FDI contributes to technology supply and energy efficiency in the host countries, which eventually control emission and improves the decarbonization scenario in those countries. However, our findings diverge with Apergis et al. (2023). Zhu et al. (2016), Shahbaz et al. (2015), Mahadevan and Sun (2020), (and Grimes and Kentor (2003) argue that FDI significantly contributes to the augmentation of carbon emissions, particularly in low-income and developing countries by taking advantage of factors like weak institutional quality and relaxed environmental regulations. Finally, our findings on the positive impact of the energy transition on decarbonization coincide with the study of Rahman et al. (2022), Sharif et al. (2021), Kacprzyk and Kuchta (2020), Rathnayaka et al. (2018), Sinha and and Bhattacharya (2017) who find that renewable energy transition significantly reduce carbon emission, which ultimately propels decarbonization effort. However, our result does not support the findings of Onifade et al. (2021) who found no existence with regard to energy transition and emission in the OPEC countries. Our findings also contradict Ren et al. (2021) who revealed that even though economic growth increases pollution, clean energy does not reduce emissions significantly in EU nations.

6. CONCLUSION AND POLICY RECOMMENDATION

Decarbonization and clean energy transition are two crucial factors for tackling climate change issues and ensuring environmental sustainability, particularly in emerging countries. Capitals markets of these countries are expected to contribute significantly to promoting the decarbonization initiative by limiting credit to fossil fuel intensive industries and investing in energy transition. This study investigates whether the capital markets of BRICS economies promote decarbonization within these countries. By applying the Driscoll-Kraay standard errors, we analyze annual data spanning from 2000 to 2021. We also apply both Fixed Effects and Random Effects Generalized Least Squares (GLS) methods to validate the empirical findings. Our results reveal that both private sector credit deepening and stock market development simultaneously promote carbon dioxide emissions, thereby undermining decarbonization efforts in BRICS economies. Moreover, we find that non-renewable energy intensity and rapid GDP growth significantly increase pollution emissions, presenting further barriers to environmental sustainability in this economic bloc. However, we find that FDI and energy transition emerge as pivotal factors driving decarbonization in BRICS economies, highlighting the importance of attracting more green FDI and transition finance.

Our study delivers fresh insights into the role of BRICS capital markets, where both private sector credit deepening and stock market development deter the decarbonization agenda by financing emission-oriented productions and processes. This scenario stresses the modification of investment and financing policies of the BRICS capital markets participants to better align with the regions' decarbonization objectives. Besides, the significant contributions of energy intensity and GDP growth to pollution emissions highlight the ongoing reliance on fossil fuels, presenting major challenges to achieving the decarbonization goal. Moreover, the study identifies FDI and energy transition as critical enablers of decarbonization, offering opportunities to achieve decarbonization through cleaner and more sustainable growth pathways within the BRICS bloc.

The findings of this research provide some significant policy implications with regard to the nexus among capital markets, energy transition, and decarbonization in BRICS countries. First, Governments in BRICS economies should regulate and reward financial institutions to allocate more capital toward green investments, such as renewable energy projects and energy-efficient technologies. In this context, framing pragmatic policies like offering tax rebates, popularizing green bonds, and imposing mandatory environmental, social, and governance (ESG) reporting can help align capital market growth with the decarbonization goal. Second, Policymakers must integrate decarbonization strategies into national economic agendas by fostering a shift toward low-carbon industries and improving energy efficiency in high-emission sectors. This can be achieved by implementing strict emissions regulations at national and regional levels, subsidizing renewable energy projects, and promoting the adoption of clean technologies across industries. Third, BRICS economies should design policies that attract FDI into clean energy sectors by providing investment guarantees, streamlined regulatory processes, and competitive incentives. Going into joint venture projects with global leaders in renewable energy can also accelerate technology transfer and capacity building, enabling faster progress toward energy transition and decarbonization. Besides, FDIs should be attracted to establishing energy-efficient production processes to accelerate the decarbonization effort in the respective BRICS countries.

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