Foreign Direct Investment and Energy Demands: What Drives Economic Growth in Emerging Economies?

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Abstract

This study addresses two central questions: (a) Do inward foreign direct investment (FDI) spillovers drive economic growth in emerging economies? and (b) How do the interconnectedness of inward FDI and energy demands cause economic growth in emerging economies? For the analysis, the study uses data from the World Development Indicators and Penn World Table 10.0, covering the period between 1994 and 2019. The results show evidence of bi-directional causality between inward FDI spillover and economic growth, and the relationships are negative. These results indicate that FDI inflows are less critical in economic growth in emerging economies and vice versa. Furthermore, non-renewable energy positively causes both economic growth and FDI inflows, whereas renewable energy negatively causes economic growth. More so, our results reveal a presence of bi-directional causality between FDI inflows and renewable energy in emerging economies. Finally, as these empirical insights have profound implications for governments and policymakers in these economies, the article proposes policies targeting sustainable economic growth and diffusions of renewable energy technologies through inward FDI spillover.

JEL Codes: 047, F35, P18, P52, C10

Keywords

Economic growth, FDI, energy demands, BRICS, PVAR, system-GMM

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Introduction

The interests of academics and policymakers in multinational corporations' activities, especially the inflows of foreign direct investments (FDIs) to emerging economies, have increased significantly in recent decades (Iheonu et al., 2024). Evidence shows that Brazil, Russia, India, China, and South Africa (BRICS) are rapidly becoming attractive destinations for FDIs (Ross & Fleming, 2023). On the one hand, due to its links to economic growth, new job creation, and global value chain promotion, governments of the BRICS are keen on attracting FDIs to their countries. For instance, China is the second-largest recipient of FDI worldwide in 2021. The annual FDI inflows to China increased from 123.99 billion U.S. dollars in 2011 to 180.96 billion U.S. dollars in 2021 (UNCTAD, 2022). According to the World Bank (2022), FDI inflows to South Africa increased from 4.14 billion U.S. dollars in 2011 to 41.29 billion U.S. dollars in 2021, amounting to over 897.66% growth. On the other hand, with factors such as abundant natural resources, market size, and flexible labour costs, it is not surprising that BRICS countries are experiencing influxes of FDIs, especially from developed economies.

At the core of this burgeoning interest is the potential spillover effect that inward FDIs hold on BRICS' economic growth (Behera, 2023). Research in international trade and growth theories suggests that recipient economies benefit from foreign multinational corporations' FDI inflow or presence (Meyer & Sinani, 2009; Romer, 1986). Prior studies show that FDI spillovers affect domestic technological innovation (Yue, 2022), capital accumulation (Demir & Lee, 2022) and economic growth (Razzaq et al., 2021). Despite several theoretical supports (Romer, 1986), the relationship between inward FDI spillovers and economic growth in BRICS economies is not straightforward, as evidenced by conflicting results (Sunde, 2017). For example, studies found positive (Dao & Ngo, 2022), negative (Hussain et al., 2021), and insignificant (Joo et al., 2022) impacts of FDIs on economic growth, respectively. Due to these inconclusive findings, scholars call for more studies to further uncover this relationship (Xiuwu et al., 2022). Addressing this research concern is particularly important as it can help policymakers and governments deploy long-term economic growth agendas driven by foreign investments. To fill this gap, this study builds on the FDI spillover framework to answer the following question: *Do inward FDI spillovers drive economic growth in BRICS countries?*

Furthermore, even though international trade, foreign investments and economic activities are rapidly growing in BRICS countries, there are concerns about their high demand for energy use. In other words, economic growth in these countries is energy-intensive, often relying on high fossil-fuel energy use. Fossil fuels still account for a more significant share of primary energy use in most emerging economies, leading to high carbon emissions. According to the BP Statistical Review of World Energy, the primary energy consumption in emerging economies increased by 15 exajoule since 2019. For instance, in 2021, China, India, the Russian Federation and Brazil, with 12039.78, 2172.12, 2797.18 and 495.82 million tonnes of carbon dioxide, respectively, are among the major carbon emitters in the world (BP-SRWE, 2023). Prior research suggests that FDI inflows by

multinational corporations contribute to energy consumption and carbon emission intensity through pollution haven and scale effects (Khan & Ozturk, 2020). These activities are detrimental to the environmental quality. Despite the contributions of extant studies, there is still insufficient evidence on how energy demands affect the inward FDI-economic growth nexus. Thus, this study fills this gap by addressing the second question: *How do the interconnectedness of inward FDI and energy demands cause economic growth in BRICS countries*? This research direction is essential in the policy domain as it can enable governments in emerging economies to implement regulations and mechanisms to reduce FDIs' excessive demands for non-renewable energy and encourage economic growth driven by clean and environmentally friendly energy options.

To answer these questions, we take advantage of unique and comprehensive panel data covering the period between 1994 and 2019. This study contributes to the literature in the following ways. First, examining the BRICS countries as the focus of the study is particularly interesting since these countries have been implementing international investment strategies and open trade policies for over two decades. Yet, it is unclear whether such initiatives are promoting long-term economic growth. For instance, scholars are asking whether FDIs in emerging economies have reached their tipping point (e.g., Sumner, 2008). In response to this call, this study contributes to the literature by enhancing our understanding of the impact of inward FDI spillover on economic development in BRICS countries.

Second, most existing studies in this field have ignored analysing the role of energy demands and energy sources in emerging economies' FDI-spillover economic growth nexus. Pursuing this research agenda is essential given that energy consumption, international investment, and economic growth may generate substantial pressure on the environment's quality. This contributes to the literature by uncovering the dynamic linkage among inward FDI spillover, energy demand and economic growth.

Third, this article contributes to the literature from a methodological perspective. Compared to the developed economies, the relationship between inward FDI spillover and economic growth in BRICS countries is largely unclear. Scholars argue that the conflicting evidence obtained in these economies is mainly due to estimation methods based on periods and mean approaches such as vector error correction (VEM), pooled ordinary least squares (POLS), etc. These approaches are limited because they utilise averages to predict outcomes; hence, they do not allow for efficient over-time-frame estimations. The current article overcomes these limitations using panel vector autoregression (PVAR) and a system-generalised moment method (system-GMM). This advanced and efficient econometric approach addresses heterogeneity, endogeneity, and time-invariant non-observed fixed effects and provides consistent and robust results. Thus, this article contributes to knowledge as one of the first studies to adopt a GMM-style PVAR approach to investigate the growth implications of the dynamic relationships between FDI spillovers and energy demands in emerging economies. Finally, this study proposes and discusses several important policies that can enable BRICS countries to drive economic growth from foreign investments, promote the diffusion of renewable energy technologies and reduce the demands for non-renewable energy.

The remainder of this article is structured as follows. The second section provides the literature review related to this study. The third section presents an overview of the data and methodology. The fourth section discusses the results of this study. Finally, the fifth section offers the policy implications and conclusion.

Literature Review

Theoretical Background on FDI Spillover-economic Growth Nexus

Growth theory and international business literature suggest that FDIs benefit recipient economies (Meyer & Sinani, 2009; Romer, 1986). Research widely agrees that inward FDIs, especially the ones from developed economies, are more productive than domestic enterprises in the host countries. For example, they are assumed to have superior technologies, knowledge resources and more efficient management practices. However, the recipient countries can benefit from the positive externalities resulting from the activities of FDIs. Todaro (1985:438) argues that FDIs 'supply a *package* of needed resources including management experience, entrepreneurial abilities, and technology skills which can then be transferred to their local counterparts through training programmes and *learning by doing*'. In other words, the activities of FDIs can spill over to emerging economies and, in turn, lead to economic growth.

Furthermore, the endogenous growth theory strongly supports FDI-induced growth through capital formation, knowledge transfer and technology diffusion (Romer, 1986). In the endogenous growth theory, FDI overperforms domestic investment in spurring long-term growth in recipient countries through constant technology shocks (Borensztein et al., 1998). Romer argues that technological change emerging from profit-maximising agents' research and development activities drives economic growth. Within this framework, the new ideas generated by multinational corporations enable them to produce new intermediate goods and new consumer products efficiently, thereby making them more profitable. Fortunately, the nonrival nature of ideas makes it possible for enterprises/agents in recipient countries to access, imitate and utilise technologies and knowledge generated by multinational corporations (Romer, 1990). In other words, FDIs by multinational corporations catalyse long-term growth through positive externalities—providing new know-how, enhanced management, technologies, resources and skills before now unknown to the recipient economies. In so doing, the spillover effect of FDI pushes the recipient economies closer to the production and technological frontier.

Research highlights various mechanisms through which recipient emerging economies can benefit FDI activities and improve their economic growth. For example, FDI can promote growth in emerging economies by enhancing knowledge level, workers' training, management practices and know-how purchasing (Zhang, 2017). Other mechanisms through which FDI-induced technology transfers and technology spillover can foster economic growth in emerging economies include the observation of foreign-invested enterprises by host country agents,

imitation of foreign technology, exporting strategies, mobility of labour, collaborations, competition, and production efficiency (Blalock & Gertler, 2008).

Despite its theoretical support, empirical studies analysing the linkage between FDI spillover and economic growth in emerging economies are far from conclusive (Ofori et al., 2023). For example, in a study based on panel data from 51 developing countries, Li and Tanna (2019) found that FDI strongly contributes to economic growth. Nonetheless, using a panel of 77 low-and middle-income countries, Abdullah and Chowdhury (2020) find that FDI does not foster growth. Lastly, Anwar and Sun (2014) show that FDI inflows have heterogeneous and curvilinear effects on economic growth in China. Despite the mixed findings in existing studies, we expect inward FDI spillover to contribute to the economic growth in emerging economies.

Interconnected Linkage Among Inward FDI, Energy Demands and Economic Growth

Energy is essential for production activities and the main driver of economic growth. On the one hand, research, especially in energy economics and environmental economics, is increasingly exploring the interconnection between economic growth and energy demands (Srinivasan & Ravindra, 2015). Literature in the field can be categorised into four main streams. The first stream—the 'growth hypothesis'—proposes that energy causes economic growth (Tang et al., 2016). The second stream—the 'conservation hypothesis'—suggests that economic growth leads to a high demand for energy (Chen et al., 2018). The third stream—the 'feedback hypothesis'—suggests the bi-directional causality between energy consumption and economic growth (Belke et al., 2011). In other words, the feedback hypothesis assumes that energy demand and economic growth are closely tied such that as economies grow, energy demand rises and vice versa (Saidi et al., 2017). Finally, the 'neutrality hypothesis' implies no statistically significant causal linkage between energy demand and economic growth (Kablamaci, 2017).

Over the past three decades, the demand for energy in emerging economies has increased enormously with the growing industrialisation, economic reforms and trade activities. According to the International Energy Agency, Brazil, China, India, Indonesia, Mexico, and South Africa consume a third of the world's energy, which is expected to rise to 40% under current policy directions. For instance, in China, energy consumption increased from 77.58 Gigajoules per capita in 2010 to 110.8 Gigajoules per capita in 2021. The oil consumption increased from 440.8 Million tonnes in 2010 to 691.6 Million tonnes in 2021, a 56.9% rise (BP-SRWE, 2023). Even though the energy demand is accompanied by prosperity, it is linked to high carbon emissions and increasing environmental challenges (Ho et al., 2024). The environmental deterioration and climate change challenges related to economic growth are raising severe concerns, thus representing a significant challenge for governments and policymakers.

In addition to the energy-growth nexus, the research explores the linkage between inward FDIs and energy demand (Mielnik & Goldemberg, 2000).

For example, they can induce a high demand for energy through industry expansion, transportation and production activities. Nevertheless, Salim et al. (2017) suggest that FDI has a positive association with energy demand in the short run but a negative impact in the long run in China. Besides, Doytch and Narayan (2016) find a negative association between FDI and energy demand. These results reveal that the direction of causality between FDI and energy demand remains an unsettled issue (Lee, 2013). Moreover, most existing studies focus on either the energy-growth nexus or the FDI-energy nexus, neglecting the dynamic interconnectedness among FDIs, energy demands, and economic growth in BRICS countries. Therefore, this study addresses this gap by uncovering the causality directions between these variables.

Data

The sample used in the study comprises annual data from five major emerging economies: Brazil, Russia, India, China and South Africa (BRICS). The data are drawn from two sources: first, the World Development Indicators (WDI) published by the World Bank, and second, the Penn World Table 10.0 (Feenstra et al., 2015). This study employs panel data from 1994 to 2019. The 27-year sample period is sufficient for a longitudinal analysis of the interconnected impacts of inward FDI spillover, energy demands and economic growth. The variables are transformed into a natural logarithm to stabilise the variance of the series and avoid incidences of heteroscedasticity. See Table 1 for details of the variables used in the analysis.

Methodology and Model Specification

This article employs the PVAR methodology, which combines the dynamic panel model and conventional VAR approach (Holtz-Eakin et al., 1988). The PVAR is an economic system model that treats all the variables as endogenous. Unlike the

Table 1. Data, Measurement and Sources.

Variable	Definition and Measure	Source
Economic growth	Gross domestic product per capita (current US$)	WDI†
Foreign direct investment	The net inflows (% of GDP) of investment to acquire a lasting management interest (10% or more of voting stock) in an enterprise operating in an economy other than that of the investor	WDI
Non-renewable energy	Fossil fuel energy consumption (% of total)	WDI
Renewable energy	Renewable energy consumption (% of total final energy consumption)	WDI
Productivity	Welfare-relevant TFP levels at current PPPs (USA=1)	PWT‡

Note: †World Bank, World Development Indicators. ‡Penn World Table, Version 10.0.

traditional time-series modelling methods, the PVAR approach accommodates unobserved individual heterogeneity (Love & Zicchino, 2006). Thus, the PVAR approach is appropriate for our investigation as it can explain the dynamic heterogeneity among the BRICS countries. The empirical model for estimating the dynamic linkages among economic growth, FDI, non-renewable energy, renewable energy and the control variable productivity is presented in Equation (1). Following Andrews and Lu (2001), we select the first-order PVAR model (lag t − 1) as the optimal lag length. Therefore, the model is specified as follows:

$$Y_{it} = \mu_i + \Phi(\mathrm{I})Y_{it-1} + v_i + \theta_t + \varepsilon_{it} \quad (1)$$

Where i = 1,2, 3….,5; t = 1994, 1995, 1996….,2019; Y_{it} is economic growth ($lnECG_{it}$), inward FDI ($lnFDI_{it}$), non-renewable energy ($lnFEN_{it}$), renewable energy consumption ($lnREN_{it}$); and given its importance on economic and energy research, productivity ($lnPRD_{it}$), which is included in the model as the control variable. $\Phi(I)$ denotes the lag operator of the endogenous covariates, v indicates an individual specific effect, θ and ε represent the fixed time effect and stochastic error term, respectively.

Given that the lagged dependent variable is not independent of the composite error process, estimating Equation (1) using conventional estimation techniques such as Ordinary Least Squares would produce biased outcomes. Hence, to adequately address this concern, the literature suggests adopting the first difference approach to eliminate the country-specific effect (Pham, 2022). Thus, Equation (2) is specified as follows:

$$\Delta Y_{it} = \Delta\mu_i + \Phi(\mathrm{I})\Delta Y_{it-1} + \Delta v_i + \Delta\theta_t + \Delta\varepsilon_{it} \quad (2)$$

Where Δ denotes the difference indicator. Owing to a strong correlation between the differenced lagged dependent variable and the error term, Arellano and Bond (1991) suggest addressing it by implementing the difference generalised method of moment (GMM). Nevertheless, differenced GMM is limited as it suffers from unbalanced panel issues and finite sample bias. To overcome these challenges and obtain consistent and efficient results, this article utilises the system-GMM (system-GMM) developed by Arellano and Bond (1998). The system-GMM uses the lagged differences of the dependent variable as instruments for equations in levels and includes the lagged levels of the dependent variable as instruments for equations in first differences. Therefore, we estimated the PVAR using the system-GMM (system-GMM-PVAR) estimator.

Empirical Results and Discussions

Descriptive Statistics

Descriptive statistics are presented in Table 2. The results show that the average growth in economic growth is 8.1%, with a standard deviation of 1.0. Besides, it

Table 2. Descriptive Statistics.

	Mean	SD	Min	Max
lnECG	8.103	1.026	5.847	9.679
lnFDI	0.531	0.803	−1.755	1.789
lnFEN	4.113	0.857	2.351	5.335
lnREN	2.814	0.972	1.157	3.922
lnPRD	0.474	0.144	0.247	0.881

Note: lnECG = Economic growth, lnFDI = Inward foreign direct investment, lnFEN = Non-renewable energy, lnREN = Renewable energy, lnPRD = Productivity.

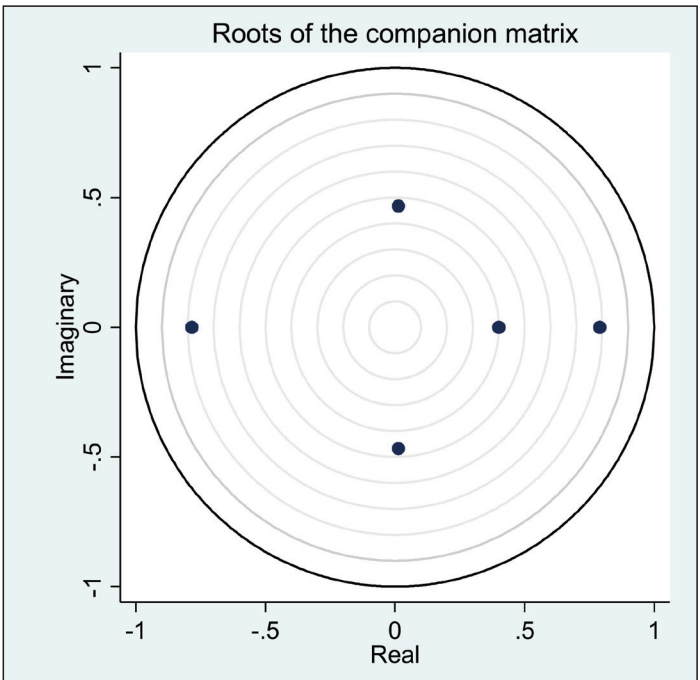
has the highest mean, followed by non-renewable energy, with a mean value of 4.1% and a standard deviation of 0.85. Renewable energy has a mean value of 2.8% with a standard deviation of 0.9, followed by the FDI with a mean of 0.53% and a standard deviation of 0.8. Finally, the standard deviations of the variables used in this study reveal a lower variability across the data points over time. Thus, we do not have outliers-related problems.

Stability Test Results

Before computing the long-run relationships among economic growth, non-renewable energy, renewable energy and the control variable—productivity, it is essential to conduct the stability test (Usman et al., 2021). The stability of the model indicates that the PVAR has an infinite vector order moving average representation, and it allows for the interpretation of the impulse response functions (IRFs) and error variance decomposition (Abrigo & Love, 2016). The stability condition for the PVAR model is that all eigenvalues of the companion matrix should be strictly less than one, therefore lying inside the unit circle (Lütkepohl, 2005). As Figure 1 shows, the stability condition is met because the modulus of each eigenvalue is less than one; thus, the PVAR model is stationary.

System-GMM-PVAR Results

The stability test results confirm that the system-GMM-PVAR estimates are reliable and consistent. This section reports the empirical results from the GMM-PVAR estimations. Table 3 presents the causal relationships between economic growth, FDI, non-renewable energy, renewable energy and the control variable, productivity. The result shows that FDI inflows into BRICS countries cause economic growth, and the relationship is negative. Thus, when economic growth decreases by 0.028%, FDI inflows increase by 1%. These results are consistent with the empirical findings that FDI inflows do not contribute to economic growth in emerging economies (Joo et al., 2022). An explanation for the negative impact may be the institution deficiencies in emerging economies (Liu et al., 2021). Research suggests that institutions' quality strongly affects the efficiency of FDIs (Palepu & Khanna, 1998).



Eigenvalue		
Real	Imaginary	
.789565	0	.789565
−.784092	0	.784092
.012734	−.467553	.467726
.012734	.467553	.467726
.399968	0	.399968

Figure 1. Stability Graph.

Table 3. System-GMM-PVAR Causality Main Results.

	Dependent Variables				
	dlnECG	dlnFDI	dlnFEN	dlnREN	dlnPRD
Independent variables					
$dlnECG_{i-1}$		−3.665***	0.258***	0.394***	−0.0171
		(0.264)	(0.0158)	(0.0219)	(0.0142)
$dlnFDI_{i-1}$	−0.028***		0.00136	0.0155***	−0.00524***
	(0.00453)		(0.00217)	(0.00327)	(0.00156)
$dlnFEN_{i-1}$	0.515***	15.51***		−1.069***	0.485***
	(0.134)	(1.071)		(0.0728)	(0.0661)
$dlnREN_{i-1}$	−0.201***	4.009***	−0.221***		−0.0691
	(0.0679)	(0.550)	(0.0445)		(0.0460)
$dlnPRD_{i-1}$	0.807***	12.36***	−0.818***	−1.140***	
	(0.126)	(0.927)	(0.0610)	(0.0716)	

Note: Heteroskedasticity robust standard errors in parenthesis. ***$p < .01$, **$p < .05$, *$p < .1$.

For example, FDIs in host countries with well-functioning institutions tend to perform better and contribute to growth. In the context of emerging economies, however, institutional factors such as fragmented financial systems, poor market infrastructure, and missing or dysfunctional legal systems heighten the operating challenges of FDIs and, in turn, negatively affect the growth rate.

Furthermore, economic growth positively causes energy demand in BRICS countries. These results show that non-renewable and renewable energy will increase by 0.258% and 0.394%, respectively, when economic growth increases by 1%. Besides, the results confirm the causality from non-renewable energy to economic growth, such that the latter increases by 0.515% when the former increases by 1%. Thus, these findings further validate the traditional assumption: as economies grow, energy demand rises and vice versa. Nonetheless, this assumption does not hold renewable energy as the results show that an increase in renewable energy by 1% leads to a decrease in economic growth by 0.201%. These results are interesting as they uncover the energy type driving economic growth in BRICS countries. In other words, economic activities in emerging economies are energy-intensive. In most cases, they involve a considerably high fossil-fuel energy use. Scholars and policymakers increasingly emphasise the need to decouple economic growth from fossil-fuel energy (Frodyma et al., 2019). Our results suggest that BRICS countries struggle to achieve economic growth through clean and renewable energy.

The results show that FDI causes renewable energy, and the relationship is positive. Thus, renewable energy increases by 0.0155% when FDI inflows into BRICS countries increase by 1%. Scholars argue that recipient countries can benefit from the positive externalities linked to the presence and activities of multinational corporations (Blomström, 1986). These results confirm that the FDI spillover mechanism by multinational corporations catalyses advancement in renewable energy technologies, thereby providing new know-how and alternative energy sources now unknown to the BRICS countries. In the same way, the results reveal a positive causality between renewable energy and FDI, such that the latter increases by 4.009% when the former increases by 1%. Taken together, these findings contribute to evidence in two main ways. First, unlike prior studies suggesting that inward FDIs are the main drivers of non-renewable energy, carbon emission intensity through pollution haven and scale effects (Khan & Ozturk, 2020), our study shows that FDI spillovers promote renewable energy, which is linked to reducing the environmental pressures. Second, the strong support revealed by our results shows that renewable energy can drive and meet the energy demands of inward FDI. Finally, we controlled for productivity, and the results show that it positively causes economic growth and FDI inflows into BRICS countries. The results imply that a percentage increase in productivity will increase economic growth and FDI by 0.807% and 12.36%, respectively. These findings are similar to those of Yalçınkaya et al. (2017).

Impulse Response Functions

In this section, we evaluate the causality's strength and impact using the IRFs developed by Love and Zicchino (2006). The IRFs are based on the Cholesky

decomposition of variance-covariance matrix residues to ensure that shocks are orthogonalised (Sims, 1980). The IRFs assess the reaction of one variable when impacted by a shock in another variable (s) while holding all shocks equal to zero (Lütkepohl, 2005). Sims (1980) suggests that the variables in the VAR model should follow a recursive causal ordering based on their degree of exogeneity. Following Sims' recommendation and economic theory, this study ordered the variables FDI, ECG, FEN, REN, and PRD. In this study, we assume that a current shock to FDI has a contemporaneous impact on economic growth, non-renewable energy, renewable energy and productivity. In contrast, economic development, non-renewable energy, renewable energy and productivity affect FDI only with their lags. We use 200 Monte Carlo simulations of a Gaussian approximation to assess the confidence intervals of IRFs based on the Cholesky decomposition (Abrigo & Love, 2016).

The results of the IRF analysis in Figure 2 show that a shock to FDI inflows initially decreases economic growth and later increases marginally and stabilises in the long run. More so, a shock to FDI inflows increases both non-renewable and renewable energy demands in BRICS countries and stabilises in the long run. Furthermore, a shock in non-renewable energy initially increases economic growth in BRICS countries and stabilises in the long run. On the other hand, innovation in renewable energy decreases economic growth in BRICS countries and increases in the long run. Finally, a shock in non-renewable energy initially improves economic growth in BRICS countries and later decreases and stabilises in the long run.

Forecast Error Variance Decomposition

Additionally, the variance decomposition is estimated to capture the causal strength of the relationship between economic growth, FDI, non-renewable energy, renewable energy and the control variable, productivity. The variance decomposition approach represents the magnitude of a predicted error variance explained by shocks from each variable, capturing the proportional contribution in one variable due to the innovations to other variables accumulated over time (Pesaran & Shin, 1998).

The results of the variance decomposition approach, as shown in Table 4, indicate that a shock to FDI inflows accounts for 0.026% of the variance in economic growth in BRICS countries, whereas shocks to non-renewable energy and renewable energy account for 0.027% and 0.069%, respectively, at the 10-years horizon. However, a shock to non-renewable energy accounts for 0.248% (as against 0.008% from renewable energy) of the variance in FDI activities for the 10 years ahead. Overall, these results show that FDI inflows are less critical in economic growth in BRICS countries, thereby validating the consistency and reliability of our causality test in Table 3.

Policy Implications

The empirical results from this study have central policy implications. They should be considered when designing and implementing policies for economic

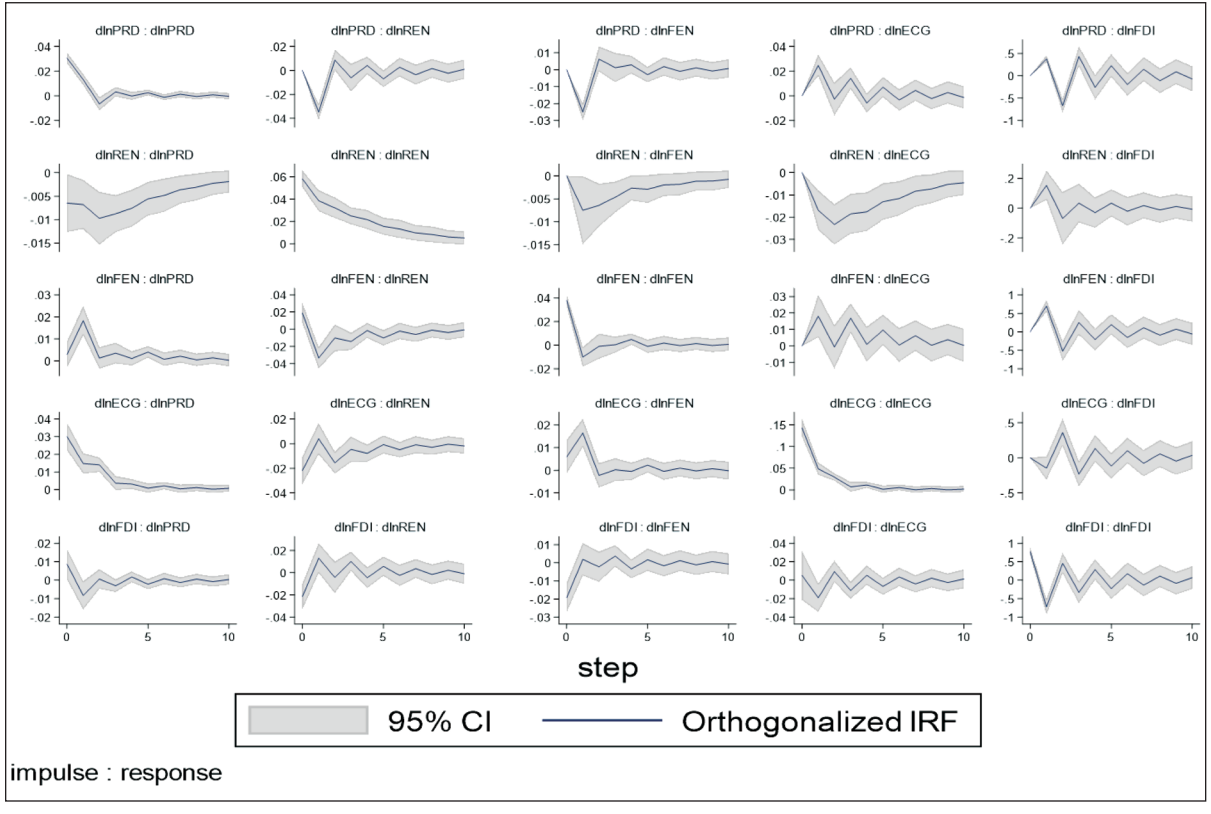


Figure 2. BRICS Impulse Response Functions.

Table 4. Forecast-error Variance Decomposition.

Forecast Horizon	Impulse Variable				
Horizon	dlnECG	dlnFDI	dlnFEN	dlnREN	dlnPRD
dlnECG					
0	0	0	0	0	0
1	1	0	0	0	0
2	0.932	0.018	0.013	0.012	0.025
3	0.912	0.019	0.013	0.032	0.024
4	0.880	0.024	0.023	0.044	0.031
5	0.868	0.024	0.022	0.054	0.031
6	0.857	0.025	0.025	0.060	0.033
7	0.852	0.026	0.025	0.064	0.033
8	0.848	0.026	0.026	0.066	0.033
9	0.846	0.026	0.026	0.068	0.034
10	0.845	0.026	0.027	0.069	0.034
dlnFDI					
0	0	0	0	0	0
1	0.001	0.999	0	0	0
2	0.017	0.618	0.272	0.013	0.080
3	0.060	0.457	0.266	0.010	0.207
4	0.071	0.430	0.252	0.009	0.238
5	0.072	0.427	0.249	0.009	0.243
6	0.073	0.422	0.249	0.009	0.247
7	0.074	0.418	0.249	0.008	0.250
8	0.075	0.417	0.248	0.008	0.252
9	0.075	0.416	0.248	0.008	0.253
10	0.076	0.415	0.248	0.008	0.254
dlnFEN					
0	0	0	0	0	0
1	0.015	0.207	0.778	0	0
2	0.104	0.132	0.529	0.019	0.216
3	0.102	0.129	0.513	0.033	0.223
4	0.101	0.132	0.507	0.039	0.221
5	0.100	0.134	0.506	0.041	0.220
6	0.101	0.133	0.502	0.043	0.221
7	0.100	0.134	0.501	0.044	0.221
8	0.100	0.134	0.500	0.045	0.221
9	0.100	0.134	0.500	0.046	0.221
10	0.100	0.134	0.499	0.046	0.221
dlnREN					
0	0	0	0	0	0
1	0.109	0.092	0.076	0.723	0
2	0.061	0.069	0.171	0.558	0.141
3	0.076	0.060	0.157	0.579	0.128
4	0.071	0.064	0.161	0.584	0.120
5	0.073	0.063	0.153	0.595	0.115
6	0.070	0.063	0.157	0.594	0.115

(Table 4 continued)

(Table 4 continued)

Forecast Horizon	Impulse Variable				
Horizon	dlnECG	dlnFDI	dlnFEN	dlnREN	dlnPRD
7	0.071	0.063	0.154	0.598	0.114
8	0.070	0.063	0.155	0.598	0.114
9	0.071	0.063	0.154	0.600	0.113
10	0.070	0.063	0.155	0.600	0.113
dlnPRD					
0	0	0	0	0	0
1	0.467	0.029	0.004	0.021	0.478
2	0.402	0.048	0.122	0.031	0.396
3	0.422	0.043	0.110	0.058	0.368
4	0.410	0.045	0.109	0.079	0.357
5	0.404	0.044	0.107	0.095	0.349
6	0.397	0.045	0.110	0.102	0.345
7	0.395	0.045	0.110	0.108	0.343
8	0.392	0.045	0.110	0.111	0.341
9	0.391	0.045	0.110	0.114	0.340
10	0.391	0.045	0.110	0.115	0.339

growth, FDI, and energy in BRICS countries. First, inward FDI is a catalyst for economic growth. Recipient countries can benefit from inward FDI flowing through knowledge spillover and advanced technology embodied in capital, as suggested by the endogenous growth theory (Borensztein et al., 1998). Conversely, our results reveal a bi-directional causality between economic growth and FDI inflows in BRICS countries. Nevertheless, FDI inflows negatively cause economic growth and vice versa. These findings suggest that policies improving the institution quality in emerging economies will attract more FDIs and contribute to economic growth. For example, they can focus on policies that enhance the effectiveness of their financial systems, market infrastructure, and legal systems to ease the operational challenges as well as provide structures that will promote technology diffusions and economic development.

Second, energy availability is essential for investments, trade, and development. Thus, for energy to significantly contribute to supporting FDI activities, economic growth and sustainability, the governments of BRICS countries should invest in policies and mechanisms that promote a compelling energy mix. Our findings reveal that economic activities in emerging economies are energy-intensive and involve considerably high fossil-fuel energy use. This has profound implications for emerging economies, given the rising environmental challenges. To address these challenges, an efficient transition to cleaner energy sources is required (Chang & Fang, 2022). Therefore, our findings suggest that policies that increase the share of renewable energy in the energy mix of the BRICS countries will promote economic growth and substantially contribute to achieving Sustainable Development Goal 7, namely, 'affordable, reliable, sustainable and modern energy for all'.

Third, our results reveal a bi-directional causality between FDI inflows and renewable energy in BRICS countries. That is FDI inflows positively cause renewable energy and vice versa. These findings suggest that policies strengthening the technological innovation ecosystem and spillover mechanisms in BRICS countries will spur the transfer of new know-how and renewable energy technologies. The effectiveness and benefits of FDI inflows to recipient countries largely depend on enabling environments. However, most existing environments and infrastructure in emerging economies tend to hamper technology diffusion and productive knowledge exchange. Therefore, governments of emerging economies should play a fundamental role in deploying initiatives and incentives and enabling environments that will support technological advancements, especially in renewable energy. For example, they can support ecosystems, industry clusters and networks that foster collaborations between foreign-invested and domestic enterprises/agents. Such an agenda has two primary positive outcomes. First, the BRICS countries can benefit from synergistic effects and green technology spillovers. Second, they can decouple the FDI activities and economic growth from fossil-fuel energy and its accompanying environmental challenges.

Conclusion

The linkage between FDI and economic growth has been a subject of research and policymaking over the past few decades. Foreign investors are increasingly targeting emerging economies due to factors ranging from natural resources to market opportunities. Given its importance, this study examined the interconnected impacts of inward FDI, energy demands and economic growth in BRICS countries from 1994 to 2019. Overall, the results from the GMM-PVAR suggest that FDI inflows play an insignificant role in driving the economic growth in BRICS countries. However, the study reveals interesting evidence: inward FDIs substantially contribute to renewable energy technology transfer, which helps mitigate carbon emissions and ensure environmental sustainability. Finally, this study has some limitations that should be acknowledged and possibly overcome in future research. The empirical analysis of this study focused on the BRICS countries. Even though these countries share characteristics with other emerging countries such as Turkey, Indonesia, Nigeria, Mexico, etc., they have unique features, opportunities and challenges. Thus, further studies should examine other emerging economies.

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Appendix: Robustness Check

We conduct additional tests to check the robustness of the GMM-PVAR estimates employing the panel Granger causality test (Abrigo & Love, 2016). As shown in Table A1, the main results are consistent with those in Table 3.

Table A1. Panel VAR-Granger Causality Test.

Equation/Excluded	χ^2	df	Prob >χ^2
dlnECG			
dlnFDI	36.758	1	0.000
dlnFEN	14.756	1	0.000
dlnrREN	8.800	1	0.003
dlnPRD	41.167	1	0.000
ALL	225.696	4	0.000
dlnFDI			
dlnECG	192.291	1	0.000
dlnFEN	209.538	1	0.000
dlnREN	53.190	1	0.000
dlnPRD	177.690	1	0.000
ALL	356.203	4	0.000
dlnFEN			
dlnFDI	0.393	1	0.531
dlnECG	266.022	1	0.000
dlnREN	24.685	1	0.000
dlnPRD	179.654	1	0.000
ALL	308.652	4	0.000
dlnREN			
dlnFDI	22.590	1	0.000
dlnECG	324.741	1	0.000
dlnFEN	215.986	1	0.000
dlnPRD	253.591	1	0.000
ALL	561.743	4	0.000
dlnPRD			
dlnFDI	11.314	1	0.001
dlnECG	1.452	1	0.228
dlnFEN	53.871	1	0.000
dlnREN	2.257	1	0.133
ALL	75.044	4	0.000

Note: Ho: Excluded variable does not Granger-cause Equation variable.
Ha.: Excluded variable Granger-causes Equation variable.

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