

# Does investment in energy matter for economic growth? Evidence from BRICS countries

Investment in  
energy

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## Abstract

**Purpose** – This study aims to explore the impact of energy investment on economic growth. Specifically, the study investigates the impact of energy consumption, foreign investment, infrastructure development, tax revenue, human capital, international tourism revenue and trade volume on economic growth.

**Design/methodology/approach** – To achieve the aim, the authors sample the 24-years (1996–2019) financial statistics of BRICS countries. Given the econometric recommendations supplemented by the Johansen cointegration test, the current study uses the fully modified ordinary least square model for regression analysis and checks the robustness through robust least square model.

**Findings** – The statistical analysis shows a direct impact of energy investment on economic growth. In addition, the statistical results indicate a positive impact of energy consumption, foreign investment, infrastructure development, tax revenue, human capital and trade volume on economic growth.

**Research limitations/implications** – The results present practical implications for policymakers regarding the adequate investment in energy production that can further promote the economic growth in BRICS countries. Policy officials should enhance the volume of renewable energy production, foreign investment and tax revenue. Additionally, it is equally suggested to policymakers regarding the development of infrastructure and human capital to ensure economic growth.

**Originality/value** – This study supplements the novel and robust evidence on investment in energy-leading economic growth.

**Keywords** BRICS, Economic growth, Energy investment, Foreign investment, Infrastructure development

**Paper type** Research paper



**JEL classification** – O10, Q43

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## 1. Introduction

In the contemporary industrialization age, the development and utilization of cost-effective energy have become a requisite among all the countries of the world. In this regard, countries try to ensure the availability of such energy sources that meet the objective of sustainable economic development. Certainly, the achievement of high economic progress is one of the major economic policy agendas of economists (Bah and Kpognon, 2021). Nonetheless, it is equally important to ensure sustainable economic growth. In parallel to economic growth, it is further necessary to mitigate the massive exploitation and depletion of natural resources. In this regard, most economies are accelerating the use of such energy sources that meet both objectives, i.e. environmental sustainability and economic growth. They are focusing on sustainability-led economic growth (Khan *et al.*, 2021b). Given that, the investment in energy sources, specifically renewable energy sources, can help to achieve such an objective. The role of cost-effective energy is admissible in boosting the pace of industrial development in any country. In addition to industrial development, the availability of enough energy resources ensures the development of household sectors and vibrates the overall economic cycles (Acheampong *et al.*, 2021). It promotes the exploration of SMEs that are the real backbone of any economy and fulfill the daily consumption needs of energy. Additionally, the development of SMEs assists in handling the other economic complexities, including unemployment and skills utilization. Backing the arguments, Azam (2019) studied the interlinkages among energy, human capital, investment and economic growth and found the unidirectional and bidirectional causality among these factors.

With the increasing trend in population around the world, the energy demand is also consistently growing. It is expected that the world income would increase by double in 2040 because of intensive increments in industrialization and technology development (Azam, 2019). With the rising prosperity, the consumption of energy will also increase in the near future. Thus, it has become necessary to make investments in the development of new energy sources for ensuring consistent economic growth. Additionally, the modification in lifestyle may demand more energy consumption and this phenomenon may become more explicit in fast-emerging economies of the world (Khan *et al.*, 2021a). Among the others, the BRICS countries are the leading economies in the race for rapid economic growth. In Asia, China and India are the eye-catching economies of the world regarding economic growth. These economies are experiencing consistent economic growth for the past decade. Meanwhile, other companion countries including Brazil, Russia and South Africa are following the same track for economic growth. Nonetheless, this upsurge in economic growth is constantly enhancing the demand for more energy in these economies. Parallely, the CO<sub>2</sub> emissions have slightly increased in this region. For instance, it is noted that CO<sub>2</sub> emissions have increased by 1.6% to 3.1% because of more non-renewable energy consumption in China (Baloch *et al.*, 2021). Similarly, India and other economies of the BRICS are experiencing the same trends regarding energy and CO<sub>2</sub> emissions. It is, therefore, necessary to invest in such energy sources that ensure sustainable economic growth.

It has been witnessed that the developing economies have attained enormous economic growth during the past two decades. Inevitably, such economies are also using the massive natural stocks that are generating many other environmental issues, including CO<sub>2</sub> emissions and exhaustion of the natural environment. According to Wu (2017), the growing industrialization has generated many environmental issues, including water and air pollution in leading economies of the world, e.g. Mexico, Brazil, India and China. More specifically, Azam (2019) has illustrated that the BRICS countries constitute above 40% population of the world and gross domestic product (GDP) as well. Both factors require more energy to fulfill

the increasing demand of the population and industrial sector, respectively. The varying trend regarding the economic growth among the BRICS nations has been observed during the past decade. Brazil and Russia are the most volatile countries regarding the economic growth in the group of BRICS. For instance, both countries experienced negative economic growth of  $-3.545\%$  (Brazil) and  $-1.972\%$  (Russia) in 2015 (shown in Table 3). By contrast, China and India have sustained their economic growth for a long time. Specifically, the average economic growth in China for the years 1996–2019 is  $8.956\%$  which is the highest among other countries in the BRICS group. This has become possible because of more investment in energy, political stability, modification in tax structure and a low inflation rate in China. Additionally, China and India are desired destinations of FDI for the rest of the world which certainly contributes to their economic growth (Bank, 2022).

This study investigates the impact of energy investment on the economic growth of BRICS countries. We further explore the linkage of energy dependency, foreign investment, infrastructure development, tax collection, human capital, tourism revenue and trade liberalization with economic growth. By using the panel data of five BRICS countries, the current study examines the underlying relationship among the variables by using fully modified ordinary least square (FMOLS) and robust least square (RLS) models. The statistical analysis discloses the significance of all aforementioned factors (excluding international tourism revenue which has an insignificant role) in boosting economic growth. The statistical results of the FMOLS model suggest that the investment in energy has a positive impact on economic progress even in long the run. This investment enhances energy production and thus ensures the consistent flow of input to the other sectors of the economy and thus positively determines economic growth. Foreign investment brings more capital into the country and eases the balance of payment. It further opens more employment opportunities. Similarly, the consumption of renewable energy has a positive spillover for economic progress because of cost-effectiveness. Infrastructure development plays a promising role in domestic growth as it facilitates other economic activities through the ease and transparent flow of traffic. Higher tax collection reduces the physical deficit and allows the country to invest in development activities. Similarly, higher human capital assists in using the existing natural resources and boost the overall production of a country. Tourism revenue accelerates the overall economic activities and ensures the flow of capital from developed to less-developed regions. This situation is more fruitful in the case of international tourism revenue. Lastly, trade liberalization provides more privileges for the transformation of knowledge and seeks the potential market for industrial goods.

The current empirical analysis contributes to the literature by exploring the role of energy investment in the economic development of the BRICS region. It provides robust evidence by controlling a list of other economic factors. The selected variables are new and highlight the dynamic trend of economic growth. The findings of the study can be considered for the development of multiple economic policies regarding the significance of energy investment. The analysis further highlights the role of various economic factors in achieving economic growth and can be a piece of guidance for economists.

## 2. Literature review

Environmental pollution occurs because of the exploitation of fossil energies and the growing demand for non-renewable energy. Some economies, e.g. the USA and China, require massive consumption of energy because of more industrial activities. However, these economies have transformed their energy demands from traditional sources of energy to renewable sources with the view of environmental protection (Ahmed and Shimada, 2019). A positive liaison has been observed between investment in energy and economic growth,

but it deteriorates the environment. However, investment in renewable energy affirms Porter's hypothesis that it elevates economic growth without harming the environment. The fossil energies are significantly determined by GDP growth in Mongolia, India, Thailand, Malaysia, UAE, Saudi Arabia and Mongolia. Fossil's energy consumption increases unidirectional economic growth but investment in natural means of energy reveals bi-directional liaison with GDP because of being eco-friendly (Lu, 2017). A direct and significant link has been discovered by various scholars between energy investment and GDP. Renewable energy-oriented economies have a long-term positive relationship with economic growth, but non-renewable oriented economies have a short-term link with GDP growth. The increase in fossil energy elevates the growth rate to some extent, but investment in renewable energies has long-term effects on economic growth (Hanif, 2018; Marinaş *et al.*, 2018).

Foreign investment (FDI) is the main source of foreign exchange assisting in smoothing the trade balance restraint on GDP growth. Furthermore, it is also a robust means of local investment that is mandatory to crane GDP growth. Ingham *et al.* (2020) approved the effect of development in different sectors of FDI in Egypt. They further reported that sectoral targeting of foreign investment plays a dynamic and significant role in boosting an economy. In the prospect of Egypt, foreign investment in the manufacturing sector had a growth effect. However, foreign investment has a positive impact on the service industry, i.e. finance and retail. Khan and Khan (2011) detected that sectoral classification regarding FDI has also an essential impact in the case of Pakistan. They also pointed out that foreign investment in the service sector enhanced economic growth, but it had a very restricted role in the manufacturing sector. Phuyal and Sunuwar (2018) asserted that FDI encourages economic growth, which discloses a direct liaison between FDI and GDP growth in Nepal. Their findings further proposed that authorities should give significance to export-oriented FDI over local demand-oriented FDI to sustain economic growth. Lund (2010) examined that FDI does not contribute as a catalyst in nurturing growth. Uwubamwun and Ajao (2012) explained that FDI has no impact on GDP growth in Nigeria. Lean (2008) has not identified a long-term connection between FDI and GDP growth in Malaysia. Similarly, Asheghian (2011) also has not observed any evidence in backing of FDI-led growth in the Canadian case throughout 32 years but noticed aggregate factor productivity and local investment as vital determinants of GDP growth. Blomström *et al.* (2003) emphasized that FDI influxes grant advantageous impact to developing economies with well-trained and educated workforce because of efficient technological spillovers.

Infrastructure development accelerates economic activities and enhances the human well-being. The construction and development of the buildings and bridges can convert agricultural regions into non-agricultural regions (urban operations), which increases business operations (Makbul *et al.*, 2019). The bridge construction linking the two regions in Indonesia is enough to include business inspectors between the two regions (Chalil, 2012). Nevertheless, infrastructure upgrading has a limited role to uplift the economy instead of developing the industrial sector (Sukma, 2015). It has evaluated infrastructure effects on county economic growth in Indonesia by using a regression approach. The research results identified a positive relationship between infrastructure investment and economic growth in Indonesia (Utami, 2009). Meanwhile, another study conducted in West Java reported that road, education and power directly affect GDP growth in West Java (Maqin, 2014). The boulevard, train track, conveyance infrastructure and energy positively affect economic growth (Palei, 2015). The infrastructure, i.e. boulevard networks, air conveyance, train track, anchorages, logistics and information hoist GDP growth. Moreover, a regression approach has been used in recognizing regional development regarding infrastructure and economies

in Spain. The transportation and communication indicators have positive and significant effects on the county economy (Cutanda and Paricio, 1994). They propose that the indicators of clinics, clean water and roads have a positive impact on GDP growth and declining poverty (Warsilan and Noor, 2015).

Contemporary literature values the role of taxation in economic growth. Up to now, growth models are more curious about the steady-state system and exogenous fluctuations. The tax collection has zero impact on GDP growth (Myles, 2000). Advancement of endogenous growth framework creates opportunities for fiscal policy, particularly tax procedures, in determining the rate of growth. Barro (1990), King and Rebelo (1990) and Jones *et al.* (1993) asserted that the degree and method of tax have an impact on an individual saving behavior and investment in human capital. Corporations form their investment decisions and innovation by following tax strategies (Johansson *et al.*, 2008). Arnold *et al.* (2011) used linear panel regression, which proposes that the country's growth performance is positively affected by property and capital transaction tax but service and commodity tax effect adversely. Moreover, property tax in the long and short term positively and significantly affects GDP growth. Such findings are persistent with the results of Acosta-Ormaechea and Yoo (2012). The property tax normally reflected a worthy revenue source for country and local administrations for granting economic and social amenities in the city. Macek (2014) and Dackehag and Hansson (2012) reported an adverse link between income and corporation tax with growth performance. Vartiai (2008) noted an inverse impact of corporation tax for OECD countries.

Empirical research verifies that marginal tax has an inverse liaison with growth, which specifies that the flying of marginal tax rate is linked with growth performance (Padovano and Galli, 2001; Lee and Gordon, 2005; Paulson and Kaplan, 2008). Mdanat *et al.* (2018) conducted an empirical analysis of the Jordanian market and found that the income tax, business tax and individual tax adversely impact growth. They further noticed that regardless of tax collection, the focus of the authorities should be on social justice for the people. Accordingly, it can be hypothesized that there is a significant link between tax collection and economic growth. Human capital (HC) plays a significant role in economic growth (Goode, 1959). Benhabib and Spiegel (1994) demonstrate that the existing situation of human capital in a state has a positive liaison with per capita income. The economies having skilled human capital can raise their economic growth with an explicit positive relationship between human capital and GDP growth (Cohen and Soto, 2007). Zhu and Li (2017) noticed a positive connection between HC and economic growth. The above-mentioned research shows that investment in human capital increases economic growth, which demonstrates a positive association between human capital and GDP growth rate.

A substantial literature exhibits the association between tourism and GDP growth rate which is specified as tourism-led growth. It increases the GDP growth rate, employment and foreign exchange. The increase in economic growth positively affects the tourism industry. It hikes activities regarding tourism by smoothing and easing infrastructures, i.e. expansion and improvement in transportation, granting awareness, introducing technological advancement, electronic money, lodges, restaurants and other entertainment services (Alhowaish, 2016). Mustafa and Majeed (2019) identified a link between FDI and tourist influx during 1976–2014 in Sri Lanka. They further found a positive relationship between GDP growth and FDI influx. Jamel (2020) suggested that, in the case of Saudi Arabia, economic growth is positively influenced by an improvement in the tourism industry. The research asserted that there is a positive liaison between tourism and economic growth, which reveals that an influx of tourists increases the revenue of the hosting state and thus upsurges economic growth.

Trade liberalization plays a backbone role for the developing and developed economies, contributing to the GDP growth rate. Moreover, economic growth is often enumerated with the GDP. The anticipated hypothesis in the literature is that trade liberalization enhances economic growth, either across economies or over time.

Foster (2008) investigated the link between exemption of formalities given by regulatory authorities in the form of trade liberalization and GDP growth, and the employment of a quantile regression approach. He further recommended that trade openness has an inverse impact on GDP growth in the short orientation; however, it has a direct impact in the long orientation. In another study conducted by Fetahi-Vehapi *et al.* (2015), there is a positive link between trade liberalization and GDP growth. Zahonogo (2016) assesses the trade liberalization effect on GDP growth in 40 states of sub-Saharan Africa during 1980–2012. He suggested that long-oriented economic fertility was affected positively by trade liberalization. The mentioned studies recommended that trade liberalization is significantly and positively associated with economic growth.

### 3. Material and methods

For empirical analysis, the current study uses the panel data of five BRICS countries, including Bahrain, Russia, India, China and South Africa for the years 1996–2019. The motivations behind the selection of BRICS countries are large industrialization, leading economies and increasing demand for energy because of massive population. All these factors urge us to perform the underlying analysis on these groups of countries. Data has been extracted from the WDI, The World Bank. This data source has been used repeatedly by previous studies and is an authentic source of data around the globe. To represent the econometric relationship between the variables, we develop the following equation:

$$\begin{aligned} GDP_{it} = & \beta_0 + \alpha_1 EGI_{it} + \beta_1 REC_{it} + \beta_2 FDI_{it} + \beta_3 IFS_{it} + \beta_4 TR_{it} + \beta_5 HCP_{it} + \beta_6 ITR_{it} \\ & + \beta_7 TDV_{it} + \varepsilon_{it} \end{aligned} \quad (1)$$

In equation (1), GDP refers to economic growth, EGI is the energy investment, REC is the renewable energy consumption, FDI is the foreign investment, IFS is the infrastructure development, TR is the tax revenue, HCP denotes the human capital, ITR is the abbreviation of international tourism revenue and TDV is the trade volume.  $i, t$  express the cross-section and time effect, respectively. Similarly,  $\beta_0$  is a constant (intercept of regression line) while  $\alpha$  and  $\beta$  represent the coefficients of explanatory variables.

#### 3.1 Variables

In the current analysis, economic growth serves as a dependent variable. It refers to the net % annual increment in GDP of a country at constant local currency. This measurement further shows the contribution of all resident producers toward the accumulated GDP (Ahmed and Shimada, 2019). Energy investment is a main explanatory variable that refers to the volume of investment made by the public sector in co-operation with the private sector for the development of new energy sources. These energy sources include all sources for electricity production, distribution and natural gas transmission. The calculation of energy investment excludes the movable assets, e.g. windmills and other small projects, and only capital expenditures were considered for the total investment. In addition to The World Bank, literature has also explained and used a similar measurement of energy investment (Azam, 2019). Similarly, energy consumption denotes the renewable energy utilization



comprises the energy from existing natural resources, e.g. wind, sun, air, etc. The production process of renewable energy does not generate negative externality in the form of pollution and is environment friendly (Acheampong *et al.*, 2021).

Foreign investment is a volume of direct investment by non-resident individuals into the capital projects of the host country. It further shows the interest of foreign investors in an industrial setup operating in the host country. The foreign investment comprises primary capital, reinvestment of earnings and equity capital that appear on the balance sheet of investing companies working in an economy other than their home country. Infrastructure development refers to the development of the transportation system and is accumulated investment in infrastructure projects that directly or indirectly serve the public and facilitate other economic activities. Tax revenue is the net collection of taxes received by the central government. It excludes the fines, penalties and other social contributions. Human capital demonstrates the total labor force that directly or indirectly participates in the production of goods and services. The measurement of human capital excludes unpaid workers, children with age less than 15 years, armed forces and students. Similarly, international tourism revenue is a net collection from non-resident individuals that come to visit the tourist's destinations, revenue from services and transportation. Lastly, the trade volume shows the sum of total exports and imports of goods and services. Table 1 presents the calculation summary of variables. The definition of variables has been specified by the World Bank. Literature has apparently mentioned these variables as determinants of economic growth (Ahmed and Shimada, 2019; Ansari *et al.*, 2020; An *et al.*, 2021; Khan *et al.*, 2021a).

### 3.2 Estimation technique

Before selecting a specific estimation technique, it is essential to investigate the various econometric issues faced by panel data. For this purpose, we first investigate the stationarity issue by using the unit root testing and select Im, Pesaran (Im *et al.*, 2003) and ADF (Dickey and Fuller, 1979) tests to check the stationarity. The statistical outputs shown in Table 5 demonstrate that most variables are suffering from stationary issues and become stationary at Level 1. This non-stationary status of variables denotes cointegration among the variables.

Variable	Role	Description	References
Economic growth	Dependent	Annual GDP growth (%)	Acheampong <i>et al.</i> (2021), Shahbaz <i>et al.</i> (2022)
Energy investment	Independent	Investment in energy with public-private investment (current US\$)	Azam (2019)
R. Energy consumption	Control	% Consumption of renewable energy	Ahmed and Shimada (2019)
Foreign investment	Control	FDI inflow (% of GDP)	An <i>et al.</i> (2021)
Infrastr. development	Control	Investment in development of transportation system (US\$)	Bah and Kpognon (2021)
Tax revenue	Control	Total tax collection (% of GDP)	Arnold <i>et al.</i> (2011)
Human capital	Control	Total labor force (numbers)	Rahman <i>et al.</i> (2021)
Int. tourism revenue	Control	International tourism receipts (% of total exports)	Khan <i>et al.</i> (2021b)
Trade volume	Control	(export + imports) in US\$	Ansari <i>et al.</i> (2020)

Source: Previous literature

**Table 1.**  
Variables summary



In the current analysis, we use the Johansen Cointegration test and adopt the Kao-residual testing to identify the cointegration. The significant probability value (shown in Table 6) of this test affirms the existence of cointegration among the variables. The current study uses the FMOLS (fully modified ordinary least squares) for empirical analysis. This model checks the regression in the long run and has the capacity to deal with other potential econometric issues, including multicollinearity and unobserved endogeneity faced by macro-panel data (data in which numbers of cross sections  $N$  are less than time  $t$ ). In addition to econometric significance, the study of Alhowaish (2016) noted that the FMOLS model provides more consistent results in presence of cointegration among the variables. They have further argued that the FMOLS model can deal with the non-stationarity behavior of regressors and heterogeneity issues as well. The implication of the FMOLS model yields an unbiased analysis in the current case. For robustness, we further use the RLS and select the M-estimation. The advantage of the RLS model is that it can deal with the outlier effect of explained variables and thus provides robust evidence. Both techniques have also been used by Azam (2019) collectively.

4. Empirical results

4.1 Descriptive and correlation summary

Table 2 presents the panel descriptive statistics for all the variables of the study. The average economic growth is 4.690% with maximum values of 14.230% and a minimum value of -7.799%. These values state the volatility of economic growth. The mean value of energy investment in logarithmic expression is 8.968. This value explains the volume of total energy investments. In addition to panel analysis, we further distinguished descriptive analysis across the countries and calculated the mean values of all variables. It can be noticed in Table 3 that China has the highest economic growth 8.956% leading to India which has 6.503% economic growth. In addition to descriptive analysis, we also present the correlation analysis in Table 4. The prevailing values of variables highlight the correlation trend among the variables.

4.2 Regression results

For empirical analysis, we mainly use the FMOLS model and report the results in Table 7. The coefficient values reveal that energy investment has a direct impact on economic growth. Following the results of the FMOLS model, the coefficient value of energy investment is 0.600, which is significant at 1% level. Similarly, the coefficient value of energy consumption is 0.024, demonstrating the significant contribution of renewable

	Mean	SD	Maximum	Minimum	Observations
Economic growth	4.690	0.074	14.230	-7.799	120
Energy investment	8.968	0.096	10.473	6.477	120
R. Energy consumption	24.722	0.057	53.767	3.180	120
Foreign investment	2.272	0.319	5.368	0.205	120
Infrastr. development	9.196	0.071	10.527	7.086	120
Tax revenue	13.802	0.087	25.048	7.982	120
Human capital	8.124	0.058	8.899	7.174	120
Int. tourism revenue	5.804	0.097	14.092	1.416	120
Trade volume	11.609	0.081	12.717	10.806	120

Table 2.  
Descriptive statistics      Source: Authors' own calculation



	Brazil	Russia	India	China	South Africa	Investment in energy
Economic growth	2.290	3.072	6.503	8.956	2.626	
Energy investment	9.790	8.461	9.324	9.059	8.208	
R. Energy consumption	45.021	3.451	43.782	18.768	12.590	
Foreign investment	3.210	2.032	1.465	3.297	1.358	
Infrastr. development	9.288	9.301	9.255	9.366	8.771	
Tax revenue	13.918	13.058	10.121	9.028	22.887	
Human capital	7.954	7.868	8.644	8.882	7.273	
Int. tourism revenue	2.658	3.445	5.037	7.885	9.996	
Trade volume	11.458	11.655	11.608	12.182	11.141	

**Note:** This table shows the mean trend of all the variables  
**Source:** Authors' own calculation

**Table 3.**  
Cross-country analysis

	GDP	EGI	REC	FDI	IFS	TR	HCP	ITR	TDV
GDP	1.000								
EGI	0.011	1.000							
REC	0.064	0.470	1.000						
FDI	0.217	0.355	0.124	1.000					
IFS	0.122	0.187	−0.028	0.235	1.000				
TR	−0.415	−0.286	−0.335	−0.261	−0.175	1.000			
HCP	0.621	0.342	0.340	0.278	0.252	−0.884	1.000		
ITR	0.145	−0.360	−0.342	−0.254	−0.225	0.417	−0.147	1.000	
TDV	0.373	0.271	−0.200	0.290	0.532	−0.478	0.636	−0.088	1.000

**Notes:** GDP: economic growth; EGI: energy investment; REC: renewable energy consumption; FDI: foreign investment; IFS: infrastructure development; TR: tax revenue; HCP: human capital; ITR: international tourism revenue; TDV: trade volume  
**Source:** Authors' own calculation

**Table 4.**  
Correlation statistics

energy consumption to economic growth. Moreover, the coefficient values of foreign investment, infrastructure investment, tax revenue, human capital and trade volume are 0.309, 0.100, 0.921, 0.451 and 0.818, respectively. These values depict the significant relationship and illustrate that a one-unit increase in the underlying variable can change the investment by the same quantity as their coefficient value holds. Nonetheless, the coefficient value of international tourism revenue is −0.173, showing the insignificant effect of ITR on economic growth.

## 5. Discussion

This study mainly finds the empirical effect of energy investment on the economic growth of BRICS countries. For empirical analysis, we use the FMOLS and RLS models and report the results in Table 7. Considering the empirical outputs of the FMOLS model, energy investment has a positive link with economic growth. This direct impact implies that expenditures that occurred on the production of energy can pay off in the form of more economic growth. The investment in energy generation induces consistent industrial growth, uplifts the depressing household sector and fulfills the immediate demand for energy for industrial fuels. The role of energy can be comprehended both in the short and

Variables	Im, Pesaran and Shin W-stat		ADF–Fisher Chi-square	
	Statistics	Probability	Statistics	Probability
Economic growth	−2.494	0.006	21.762	0.016
Energy investment (−1)	−6.952	0.000	61.703	0.000
R. Energy consumption (−1)	−2.635	0.004	27.781	0.002
Foreign investment	−1.745	0.039	19.876	0.034
Infrastr. development	−1.372	0.081	16.574	0.085
Tax revenue (−1)	−4.057	0.000	36.380	0.000
Human capital (−1)	−1.746	0.043	21.852	0.015
Int. tourism revenue	−1.687	0.045	17.793	0.056
Trade volume (−1)	−3.348	0.004	28.653	0.001

**Table 5.**  
Unit root testing

**Note:** Most variables are stationary at level 1  
**Source:** Authors' own calculation

Test name	Kao residual cointegration test	
	<i>t</i> -statistics	Probability
ADF	−2.480	0.006
Residual variance	8.246	—
HAC variance	2.618	—

**Table 6.**  
Cointegration  
diagnostic

**Note:** The significant value of ADF rejects *H*<sub>0</sub>: i.e. no cointegration  
**Source:** Authors' own calculation

	Dependent variable = economic growth			
	FMOLS		RLS	
	Coefficient	Probability	Coefficient	Probability
Constant	—	—	−3.365***	0.000
Energy investment	0.600***	0.028	0.435*	0.101
R. Energy consumption	0.024***	0.004	0.094***	0.000
Foreign investment	0.309***	0.034	0.301**	0.070
Infrastr. development	0.100**	0.078	0.403***	0.024
Tax revenue	0.921***	0.000	0.556***	0.000
Human capital	0.451***	0.015	1.969***	0.000
Int. tourism revenue	−0.173	0.340	0.218	0.146
Trade volume	0.818**	0.050	3.907***	0.000
Adjusted <i>R</i> -square	0.543		0.496	
SE of regression	0.049		—	
Akaike info criterion	—		147.947	
Long-run variance	3.605		—	
Prob. (Rn-squared statistics)	—		0.000	

**Table 7.**  
Energy investment  
as a determinant of  
economic growth

**Note:** \*\*\* denotes significance at 1%; \*\* represent the significance at 5% and \* at 10% level  
**Source:** Authors' own calculation

long run. Any investment in renewable energy brings long-term benefits as it ensures both economic growth and environmental sustainability. However, non-renewable energy uplifts economic growth in the short run, creating many negative externalities regarding the exploitation of natural resources and environmental degradation in the long run. A country with more investment in the energy sector can produce more energy, enhancing the production capacity to maximum levels and leading to the production of more goods and thus more export-led growth. Supporting this, [Azam \(2019\)](#) has clearly stated the direct impact of energy investment on economic growth. Similar to energy investment, the consumption of renewable energy has a direct impact on economic growth as it is cost-effective, has less negative externality regarding environmental degradation and requires no extra cost for production. More reliance on renewable energy can expedite economic growth through the cycle of environmental sustainability and the protection of human health ([Ahmed and Shimada, 2019](#)).

Foreign investment has a positive link with economic growth. To achieve economic diversification, the countries encourage the inflow of foreign investment. In companion to other benefits, the inflow of foreign investment generates more employment opportunities and directly contributes to the net production of a country. By locating the investment in other countries, the foreign companies are directly involved in the production operations, resulting in the transfer of knowledge, skills, technology and money. All these factors boost economic growth ([Ingham et al., 2020](#); [Khan and Khan, 2011](#); [Phuyal and Sunuwar, 2018](#)).

The positive impact of infrastructure development facilitates the functioning of other economic sectors through a smooth transportation system. Specifically, the development of transportation systems has a lasting impact on economic growth as it eases the flow of transportation systems and other industrial goods that further accelerate economic growth ([Makbul et al., 2019](#); [Sukma, 2015](#); [Palei, 2015](#); [Warsilan and Noor, 2015](#)). Similarly, tax revenue has a positive correlation with economic growth. Higher tax revenue allows the country to deliberately perform development projects and thus boost economic growth. Additionally, higher tax collection reduces the physical deficit of a country and thus less dependency on foreign debts. More tax collection augments the pace of technology development and more spending on human well-being. Both factors positively influence economic growth ([Myles, 2000](#); [Arnold et al., 2011](#); [Acosta-Ormaechea and Yoo, 2012](#)).

Similarly, human capital has a direct impact on economic growth. The availability of human capital makes it possible to use the factors of production at the maximum level. For instance, China and India have the highest labor force as compared to the rest of the world and thus both countries are leading the world in the category of rapid-economic growth. Human capital is a necessary pillar of economic growth because it augments the production capacity of existing sources through knowledge and skills ([Makbul et al., 2019](#); [Sukma, 2015](#); [Utami, 2009](#); [Maqin, 2014](#); [Warsilan and Noor, 2015](#)). Nonetheless, international tourism revenue has an insignificant effect on economic growth. Lastly, the trade volume has a direct impact on economic growth. Higher trade volume demonstrates the excessive production of domestic goods and thus more exports ([Alhowaish, 2016](#); [Mustafa and Majeed, 2019](#); [Jamel, 2020](#)). It further shows that a country is more open to trade operations that attract investors and importers. In addition to monetary benefits, the higher trade volume ensures the sharing of knowledge, transfer of favorable competition regarding the product modification and approach of domestic producers to the international market to sell their products. These factors encourage producing more goods and thus substantially promote economic growth ([Foster, 2008](#); [Fetahi-Vehapi et al., 2015](#); [Zahonogo, 2016](#)). Briefly, it can be expressed that in addition to energy investment, renewable energy consumption, foreign investment,

infrastructure development, tax revenue, human capital and trade volume are the key drivers of economic growth.

In addition to routine determinants, the current analysis contributes to the existing literature on how investment in energy also promotes the economic progress of a country. Some recent studies have explored the positive impact of energy consumption, specifically renewable energy consumption on economic growth (Marinaş *et al.*, 2018; Ahmed and Shimada, 2019; Acheampong *et al.*, 2021). However, the current analysis is innovative by augmenting the significance of energy investment in economic growth. It further includes the other determinants that were explored by the previous literature, and it provides robustness to empirical analyses of existing studies. Highlighting the sample significance, the BRICS nations are the key emerging economies of the world and have a significant contribution to total world GDP accumulations. Therefore, investigating the underlying relationship between energy investment and economic growth can provide better insights into the role of energy investment in boosting economic growth.

## 6. Conclusion and policies

This study empirically evaluated the impact of energy investment on the economic growth of BRICS countries. The empirical analysis includes other factors, i.e. foreign investment, energy consumption, infrastructure development, tax revenue, human capital, international tourism revenue and trade volume. For empirical analysis, we considered the 24-years (1996–2019) financial information as a sample and used FMOLS and RLS models. The empirical results revealed the direct impact of energy investment on the economic development of BRICS countries. The analysis further showed the direct impact of other variables excluding international tourism revenue, which has an insignificant role in determining economic growth. The investment in energy production uplifts the overall economic growth by supplementing the consistent electricity for production activities and thus results in positive economic growth. Similarly, the consumption of renewable energy is a cost-effective source of energy. Foreign investment boosts economic growth by direct contribution to the production activities of the host country. Infrastructure development facilitates the other economic sectors and induces more economic expansion. Meanwhile, tax revenue reduces the physical deficit and human capital maximizes the utilization of factors of production. Lastly, trade volume boosts economic growth by giving an opportunity to approach the international market for selling industrial goods.

Based on the results, it is suggested that policy officials of BRICS countries should enhance the investment in energy production. Any investment in energy pays off in the form of more economic growth. The production of sufficient energy is vital to ensure consistent economic growth. Moreover, the investment in energy can be boosted by inviting private investors and entrepreneurs. As the BRICS economies have the largest industrial zone, the policy officials from these economies should ensure more flow of both private and public investment to this sector. The aim of sustainable economic growth can be achieved by making an equal investment in renewable sources of energy. Furthermore, it is recommended that the policy officials should pay attention to other factors that have a promising role in the economic growth of BRICS countries. They should enhance the dependency on renewable energy consumption as it not only accelerates economic growth but also ensures environmental protection. Similarly, they should develop some policy incentives that attract more foreign investors. Policy officials should also develop the infrastructure as it facilitates the smooth functioning of overall economic activities.

Infrastructure development can make economic activities more transparent by facilitating better communication and transportation system which substantially have a positive impact on economic growth. Therefore, it is recommended to enhance the expenditures on infrastructure development. Despite the policies, the current study failed to highlight the individual trend of countries. However, a similar narration can be built because of the compilation of all countries in a single specific group. Future studies can be conducted by considering the investment in various sources, e.g. renewable and non-renewable, and how this investment affects economic growth.

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