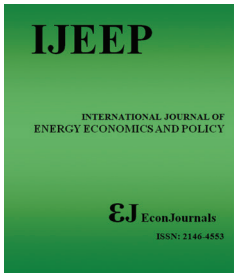

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The Interrelationships among Transportation Services, Exports, Renewable Energy Consumption, Industrial Production, and Economic Growth: A Dynamic Panel Data Approach in BRICS Countries

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ABSTRACT

This study examines the relationships between transportation services, exports, renewable energy consumption, industrial production, and economic growth using data from BRICS countries (Brazil, Russia, India, China, and South Africa) for the period from 1994 to 2023. After assessing cross-sectional dependence and the stationarity of the data series, a dynamic panel data analysis was conducted. The results of the Hausman test confirmed the validity of the random effects model. The findings reveal that exports, industrial production, and renewable energy consumption have positive and statistically significant effects on economic growth. This indicates that enhancing production capacity and increasing the use of renewable energy contribute to long-term growth. Conversely, while the impact of transportation services on growth is positive, it was not statistically significant, suggesting that the effects of the transportation sector on economic growth are indirect and manifest over time. When analyzing country-fixed effects, it was found that economic growth is above the panel average for China and India, while it falls below the average for Brazil and Russia. In conclusion, the study suggests that a growth model focused on renewable energy, production, and exports is the most suitable approach for sustainable economic development in BRICS countries.

Keywords: BRICS, Transport Service, Export, Renewable Energy Consumption, Industrial Production, Economic Growth
JEL Classifications: C13, C20, C22

1. INTRODUCTION

Over the last three decades, the global economy has transformed significantly, reshaping production centers and trade networks. Globalization and the liberalization of capital movements, which gained momentum in the early 1990s, have led to a rapid increase in the share of developing countries within the global economy. In this new era, the BRICS countries - Brazil, Russia, India, China, and South Africa - have emerged as key representatives of emerging markets, influencing global growth and trade.

The term "BRICS" was first introduced in 2001 by Jim O'Neill, an economist at Goldman Sachs, in his report titled "Building Better Global Economic BRICs." O'Neill predicted that these four countries would play a significant role in shaping the future of the world economy due to their economic size, demographic

potential, and production capacity. Later, in 2010, South Africa was added to the group, changing the acronym from "BRIC" to "BRICS." This expanded group now represents Asia, Europe, Latin America, and Africa in the global economy (Thussu, 2018).

The institutional foundation of BRICS dates to the first meeting of foreign ministers in St. Petersburg in 2006. The first summit of heads of state took place in Yekaterinburg in 2009, marking the formalization of economic and political cooperation among its members (BRICS, 2010). The establishment of the New Development Bank (NDB) and the Contingent Reserve Arrangement (CRA) in 2014 exemplified the BRICS countries' desire for independence within the international financial system. Through these institutions, BRICS has not only strengthened its economic solidarity but also created an alternative framework to Western-based financial institutions like the IMF and the World Bank (Jash, 2017).

Currently, BRICS countries account for approximately 41% of the world's population, 25% of global gross domestic product (GDP), and about 15% of world trade (Kumar et al., 2024). These ratios reflect their economic size and significance in the global balance concerning production, trade, and energy consumption. Since the 2000s, BRICS nations have positioned themselves as representatives of a multipolar economic order, opposing the unipolar structure of the global system (Andre et al., 2018).

Although these countries differ in their economic structures, production patterns, and development strategies, they share common traits such as high growth potential, population density, abundant natural resources, and increasing volumes of foreign trade. China has become the world's largest manufacturing center due to its export-oriented production strategy and industrial policies (Morrison, 2019), while India has achieved global competitiveness through its information technology and service sectors (Haqqani, 2014). Russia's economy is heavily reliant on energy exports, making it sensitive to fluctuations in oil and natural gas prices (Mau, 2018). Brazil, with its diverse production in agriculture and industry, stands as the strongest economy in Latin America (Avritzer, 2019). South Africa, rich in mineral reserves such as gold, platinum, and diamonds, serves as the industrial hub of the African continent (Cook, 2013).

The 2008 global financial crisis decelerated economic growth in developed nations while accelerating the rise of BRICS countries. In the post-crisis period, increased trade protectionism and the restructuring of global supply chains prompted BRICS nations to adopt growth models focused more on domestic demand, energy efficiency, and sustainability (Rasool et al., 2021). During this time, the relationships among transportation services, exports, renewable energy consumption, industrial production, and economic growth became significant areas of interest in the fields of energy economics and development.

In fact, a study conducted by Chang and Fang (2022) examined the renewable energy-based growth hypothesis in BRICS and N-11 countries and found a positive, two-way causality between renewable energy consumption and economic growth. Similarly, Anser et al. (2024) demonstrated a reciprocal relationship between energy consumption, technological innovation, and economic growth using the GMM Panel VAR approach. These findings indicate that renewable energy sources and technological advancements are among the primary factors driving growth in BRICS countries.

The effects of industrial production and foreign trade on economic growth have been extensively discussed in the literature. Kutu and Ngalawa (2016) highlighted that fluctuations in industrial production in BRICS countries are highly sensitive to capital flows and export performance. Bhattacharya and Bhattacharya (2016) demonstrated a long-term positive impact of foreign trade on economic growth in BRICS countries through panel cointegration and causality analyses. Similarly, Aldakhil et al. (2018) argued that green logistics, energy efficiency, and transportation infrastructure are critical for economic growth and environmental sustainability in BRICS nations. Furthermore, Chandrasekaran (2024) showed via panel data analysis that value added production in agriculture contributes to the sustainability of long-term growth in BRICS countries.

These multidimensional relationships illustrate that the economic structure of BRICS countries is complementary not only at the sectoral level but also in the realms of energy, manufacturing, and transportation. However, there are limited studies that systematically examine the dynamics and interactions of these variables over an extended period (1994-2023). This creates a methodological gap, particularly in analyzing the complex causal structure between transportation services, exports, renewable energy consumption, industrial production, and economic growth in BRICS nations. Therefore, this study aims to empirically assess the short- and long-term relationships between these variables using dynamic panel data analysis for the period 1994-2023. Dynamic panel models can statistically reveal both the common and distinct aspects of the economic performance of the BRICS countries by considering time-lagged effects and country-specific differences. In this context, the study seeks to address empirical gaps in the literature and provide guidance to policymakers regarding sustainable growth, renewable energy transition, and logistics infrastructure policies for BRICS nations.

2. LITERATURE REVIEW

The interaction among economic growth, energy consumption, industrial production, exports, and transportation services - especially in the context of BRICS countries - is a crucial area for analyzing the structural transformation processes of emerging economies. As emphasized previously, the BRICS countries emerged as significant players in global energy supply, production capacity, and foreign trade volume during the 1994-2023 period. Consequently, the literature has expanded with studies aiming to empirically validate the renewable energy-based growth hypothesis and to analyze the direct and indirect effects of the relationships among industrial production, trade, and transportation on macroeconomic growth. Various methodological approaches-including panel cointegration, panel causality, GMM, and dynamic panel data analysis - have been employed to explain

the short - and long-term relationships between these variables. This section will comparatively review national and international studies examining the effects of energy consumption, industrial production, transportation services, and exports on economic growth, focusing on their methodological differences and the direction of their findings.

Rasool et al. (2021) investigated the relationship between tourism and economic growth in BRICS countries using panel data. Their study, covering 2000-2017, examined the long-term cointegration relationship between the variables through panel cointegration analysis. The findings indicate a significant and positive relationship between tourism revenues and economic growth in BRICS countries. The research revealed that the tourism sector significantly contributes to economic development, especially in rapidly growing economies such as China and India, while the effect is more limited in Brazil and South Africa. Additionally, the panel causality analysis identified a unidirectional causality running from economic growth to tourism, supporting the "growth-tourism hypothesis." Rasool et al. emphasized that tourism activities are vital for supporting growth in BRICS countries through increased investment, employment, and foreign income. Their study suggests that investments in the tourism sector can play a strategic role for policymakers in ensuring long-term macroeconomic stability.

Chang and Fang (2022) empirically tested the renewable energy-based growth hypothesis in the BRICS and N-11 economies. The study utilized data from 1995 to 2019 and employed panel causality and panel cointegration analyses to account for cross-country heterogeneity. The primary objective was to reveal both the long - and short-term interactions between renewable energy consumption, economic growth, CO_2 emissions, and capital formation. The findings identified a bidirectional causal relationship between renewable energy consumption and economic growth, supporting the renewable energy-based growth hypothesis. Furthermore, the research determined that renewable energy consumption positively affects economic growth in the long term, although this effect is limited in the short term. The analysis indicates that energy efficiency, technological innovation, and increased investment bolster economic growth in the BRICS countries. Notably, renewable energy investments play a significant role in the macroeconomic performance of China, India, and Brazil. The study also revealed that renewable energy consumption reduces environmental degradation in terms of carbon emissions, providing a growth model compatible with sustainable development goals. Chang and Fang (2022) concluded that diversifying energy policies, increasing green investment incentives, and supporting innovation in energy technologies are crucial for achieving long-term growth and environmental stability in the BRICS and N-11 countries.

Anser et al. (2024) analyzed the dynamic relationship between energy consumption, technological innovation, and economic growth in the BRICS countries. Covering the period from 1990 to 2021, the study used a GMM-based panel VAR model to address endogeneity and country heterogeneity. The findings revealed a bidirectional causal relationship between energy consumption and technological innovation. This suggests that technological progress enhances energy efficiency, while economic growth fuels energy demand. The research highlighted that technological innovation supports growth in China and India, whereas energy consumption is the primary driver of growth in Brazil and South Africa. Overall, the study demonstrates that technological innovation contributes to sustainable growth by reducing energy intensity, and that innovation-based energy policies are essential for long-term prosperity in the BRICS economies.

Kutu and Ngalawa (2016) examined the dynamics of industrial production in the BRICS countries. Utilizing data from 1990 to 2014, the study analyzed the interactions between economic growth, foreign trade, energy consumption, investment, and employment variables using panel cointegration and a vector error correction model (VECM). The findings indicate a strong and positive long-term relationship between industrial production and economic growth, suggesting that increases in industrial production directly support total output and export performance in the BRICS economies. Moreover, the researchers found that changes in capital accumulation and foreign trade volumes are determinants of industrial production in the short term. The authors emphasized that industrial production serves as a significant driver of economic growth, particularly in China and India, while energy supply and export prices have a greater influence on industrial production in Russia and South Africa. The study highlights the strategic importance of industrial production for sustainable economic growth and demonstrates that production-based development policies support long-term prosperity in BRICS countries.

Bhattacharya and Bhattacharya (2016) investigated the long-term relationship between international trade and economic growth in the BRICS countries. Using annual data from 1992 to 2013, the study examined the linkages among variables through panel unit root, panel cointegration, and panel causality tests. The results indicated a positive and significant long-term relationship between international trade and economic growth. The findings established that exports contribute to economic growth and that greater openness to international markets, along with increased production, is a major determinant of growth in BRICS countries. Additionally, the causality analysis showed a unidirectional flow from exports to economic growth, supporting the "export-led growth hypothesis." The study emphasized the positive effects of increased international trade volumes on production capacity and employment in the economic development processes of BRICS countries.

Aldakhil et al. (2018) analyzed the factors influencing green logistics practices in BRICS countries. The study utilized panel data covering the period from 1995 to 2016, examining economic, environmental, and technological influences on green logistics within the framework of an integrated supply chain model through panel regression and panel causality analyses. Their findings revealed that energy efficiency, environmental policies, R&D expenditures, and transportation infrastructure are the strongest determinants of green logistics. A significant relationship was observed between the decrease in energy intensity and the increase

in green transportation activities, particularly in China and India. Additionally, the study concluded that economic growth and rising export volumes encourage investments in environmentally friendly logistics. The authors emphasized that integrating sustainable supply chain management and environmentally friendly transportation infrastructure into the economic growth processes of BRICS countries is essential for both environmental sustainability and competitiveness. Their research significantly contributes to the literature by demonstrating that green logistics is not only an environmental necessity but also a strategic element of sustainable economic development.

Chandrasekaran (2024) examined the impact of agricultural value added on economic growth in BRICS countries using panel data. The study, which covers the period from 1990 to 2020, analyzed the long- and short-term relationships among agricultural value added, energy use, exports, and GDP through panel cointegration and panel causality tests. The findings indicate a positive and significant long-term relationship between agricultural value added and economic growth. Increased agricultural production appears to support economic growth, particularly in Brazil and India, while in China and Russia, the agricultural sector and industrial production create an indirect growth effect. Furthermore, the study found that energy consumption plays a complementary role in enhancing agricultural productivity. The results highlight the strategic importance of the agricultural sector for ensuring food security, employment, and sustainable development within BRICS economies.

Chhabra et al. (2023) analyzed the key factors shaping economic growth in BRICS countries, focusing on the role of institutional quality and trade openness. Their study covers the period from 1996 to 2020 and employs panel cointegration and panel causality analyses to test the long-term relationship between institutional indicators and economic growth. The findings indicate that both institutional quality and trade openness have a significant positive impact on economic growth. The findings show that institutional quality and trade openness have a significant and positive effect on economic growth. Trade liberalization policies especially has a strong effect on growth in China and India, while weak institutional stability in Russia and South Africa poses a limitation on growth rates. Additionally, the authors found that improving institutional quality enhances economic performance through capital accumulation and foreign investment. The study emphasizes the critical need to strengthen institutional frameworks and increase trade integration to ensure the sustainability of economic growth in BRICS countries.

Simo-Kengne and Bitterhout (2023) examined the impact of corruption on economic growth in BRICS countries using panel data analysis. Their study, which spans from 2001 to 2019, utilized the corruption perception index, investment rate, foreign trade openness, foreign direct investment, and GDP variables. The researchers applied a panel cointegration test to identify long-term relationships and used a panel error correction model (VECM) to explore causal relationships. The findings indicate that corruption has a statistically significant negative impact on economic growth. This effect is particularly pronounced in countries with high corruption levels, such as Russia and South Africa, while it is relatively weaker in China and India due to their robust institutional frameworks. The study also noted that corruption disrupts the investment climate, reduces capital accumulation, and hinders the sustainability of foreign investment. The authors emphasize that strengthening institutional reforms and implementing anti-corruption policies are crucial for fostering long-term growth in BRICS countries. Consequently, by highlighting the relationship between economic growth and corporate governance, this study provides an original contribution to the literature on the interaction between corruption and growth in BRICS nations.

Malik et al. (2023) examined the impact of foreign direct investment (FDI) on the economic growth of the BRICS countries. Covering the period from 1995 to 2021, they employed a Bayesian Vector Autoregression approach, which differs from traditional panel methods. This method allowed the assessment of cross-country heterogeneity with probabilistic estimation intervals, providing a detailed analysis of the dynamic relationships between variables. The research findings indicate a positive and significant relationship between FDI inflows and economic growth. Notably, the strong influence of foreign capital inflows on production capacity, employment growth, and export performance was especially observed in China, India, and Brazil. Conversely, political instability and market volatility were found to weaken the impact of foreign investment in Russia and South Africa. Furthermore, the study revealed a bidirectional causal relationship, where economic growth also stimulates FDI flows. The authors emphasize that FDI is a vital component of sustainable growth strategies in the BRICS countries, highlighting the importance of improving the investment environment for long-term economic prosperity.

Recent studies have also explored the effects of energy, production, and trade dynamics on economic growth in various emerging economies outside the BRICS, utilizing different methodological approaches. Abdibekov et al. (2024) investigated the relationship between energy consumption, industrial production, and economic growth in Kazakhstan using the ARDL bounds test approach, finding long-term cointegration among these variables. Similarly, Aidarova et al. (2024) examined the effects of renewable energy consumption, industrial production, and agricultural sector growth on economic growth in OPEC countries using the panel ARDL method and concluded that renewable energy positively affects economic growth. Lukhmanova et al. (2024) studied the relationship between energy consumption and economic growth in Kazakhstan and Azerbaijan using the Toda-Yamamoto causality test, finding a significant causal relationship between energy consumption and economic growth in Kazakhstan, while this relationship was not statistically significant in Azerbaijan. Furthermore, Baimagambetova et al. (2025) demonstrated in their study - examining the impact of energy consumption, employment, mining, and FDI on economic growth - that energy supply and the labor market are among the primary determinants of growth. Collectively, these studies highlight the critical role of energy consumption, production, and trade indicators in sustaining economic growth, not only in BRICS nations but also across different country groups, thereby supporting the modeling approach of this study.

The literature summarized above reveals that the key factors determining economic growth in the BRICS countries possess a multidimensional and dynamic structure. Previous studies have tested the effects of variables such as energy consumption, industrial production, transportation, foreign trade, FDI, institutional quality, and environmental sustainability on economic growth using various methods. However, there is a limited number of studies that evaluate the long - and short-term effects of these variables within the same model framework. Therefore, a comprehensive analysis of the relationship between transportation services, exports, renewable energy consumption, industrial production, and economic growth in the BRICS countries is crucial. This analysis aims to fill the theoretical literature gap and provide practical implications for policymakers. Accordingly, the next section presents a detailed overview of the study's dataset, model structure, and methodological framework based on dynamic panel data analysis, with the goal of empirically testing the multidimensional interactions identified in the literature.

3. METHODS

This section outlines the methodological framework used to examine the relationship between transportation services, exports, renewable energy consumption, industrial production, and economic growth in the BRICS countries. The study employs an empirical approach based on panel data analysis, using annual data from 1994 to 2023. This period encompasses both the institutionalization of the BRICS concept in the literature and the significant transformations experienced in the countries' production, energy, and trade dynamics.

The research model is based on dynamic panel data analysis, which is widely used in the literature. This method is chosen because it addresses endogeneity issues that arise from past values of variables affecting economic growth, allowing for a joint analysis of both short - and long-term effects. In dynamic panel data analysis, time-series effects and country-specific heterogeneity are considered by including the lagged value of the dependent variable in the model.

The generalized method of moments (GMM) is employed for model estimation, as it minimizes potential issues of simultaneity among variables. Additionally, by using the system GMM estimator, statistical challenges specific to panel data - including cross-sectional dependence and autocorrelation - are controlled. Therefore, the model aims to reliably uncover the dynamic determinants of economic growth in the BRICS countries.

The variables included in the analysis - economic growth (GDP), export volume, transportation services, renewable energy consumption, and industrial production - are key indicators representing the development and production structure of these countries. Data for these variables were obtained from the World Bank (World Development Indicators - WDI) and OECD databases. All series were logarithmically transformed and subjected to panel unit root tests to ensure stationarity.

This methodological framework enables a multidimensional analysis of the determinants of sustainable growth in BRICS countries. The following subsection will present the theoretical foundation of the model, the definitions of the variables, and the steps for econometric testing in detail.

3.1. Theoretical Basis of the Model and Definitions of Variables

The theoretical foundation of this study is grounded in endogenous growth theory, openness to global markets, and energy-based growth models, which aim to explain the multidimensional determinants of economic growth. The endogenous growth approach posits that technological development, capital accumulation, foreign trade, and energy use have both direct and indirect impacts on economic growth (Romer, 1990; Lucas, 1988). Within this framework, the productivity of production factors increases not only with capital growth but also through the efficient utilization of knowledge, technology, and energy resources.

The literature highlights that growth dynamics, particularly in emerging economies such as the BRICS countries, are strongly correlated with energy, production, trade, and transportation indicators (Chang and Fang, 2022; Anser et al., 2024; Kutu and Ngalawa, 2016). Consequently, the model developed in this study is structured around five key variables that influence economic growth:

3.1.1. Economic growth (GDP)

Economic growth is the dependent variable of the model, measuring the macroeconomic performance and growth capacity of countries. GDP is presented in US dollars at current prices and has been logarithmically transformed for the analysis. This variable captures the long-term development trends of the BRICS countries and serves as the primary reference point for evaluating the impact of other explanatory variables on growth.

3.1.2. Exports (EXG)

Exports are a component of economic growth that occurs through increased openness. In accordance with the "export-led growth hypothesis," a rise in foreign trade volume enhances production capacity and stimulates investment by boosting foreign exchange revenues (Bhattacharya and Bhattacharya, 2016). In the model, exports from BRICS countries are included as a factor that reinforces the indirect effects of industrial production and energy-intensive sectors on growth.

3.1.3. Renewable energy consumption (RNC)

Renewable energy consumption represents the sustainability aspect of economic growth. Chang and Fang (2022) found a positive causal relationship between renewable energy consumption and growth in their study. This variable reflects the environmentally friendly nature of growth, emphasizing energy efficiency and the reduction of carbon emissions.

3.1.4. Industrial production (NDS)

The industrial production index is a crucial component of economic growth in terms of both production capacity and job creation. Kutu and Ngalawa (2016) demonstrated that increases in industrial production in BRICS countries positively impact growth and enhance foreign trade performance. Therefore, this variable

is included in the model to assess the contribution of fluctuations in real production activity to overall growth.

3.1.5. Transportation services (TRS)

Transportation services are a crucial infrastructural factor that ensures the efficient functioning of both foreign trade and internal production networks. Aldakhil et al. (2018) stated that transportation infrastructure, along with energy efficiency and green logistics capacity, plays a significant role in economic growth. In this context, transportation services are considered a structural component of growth, reflecting countries' logistics efficiency and trade costs. This model structure illustrates that economic growth in BRICS countries is influenced not only by production and export channels but also by energy transformation and transportation infrastructure.

The next subsection will detail the econometric equation, characteristics of the dataset, and testing procedures of the model.

3.2. Econometric Structure of the Model and Dataset

This study aims to empirically examine the dynamic relationships between transportation services, exports, renewable energy consumption, industrial production, and economic growth in BRICS countries. To achieve this, a dynamic panel data model was developed to explain the causal relationships between the variables. The general form of the model is specified as follows:

$$GDP_{it} = \alpha_i + \beta_1 GDP_{i,t-1} + \beta_2 TRS_{it} + \beta_3 EXG_{it} + \beta_4 RNC_{it} + \beta_5 NDS_{it} + \varepsilon_{it} \quad (1)$$

In this equation:
GDP_{it}: Represents the economic growth (GDP) of country i in period t.
TRS_{it}: Represents the transportation services variable.
EXG_{it}: Represents the export volume.
RNC_{it}: Represents renewable energy consumption.
NDS_{it}: Represents the industrial production index.
α_i: Represents country fixed effects.
ε_{it}: Represents the error term.

The inclusion of the lagged value of the dependent variable ($GDP_{i,t-1}$) may lead to an endogeneity problem. To address this, the generalized method of moments (GMM), developed by Arellano and Bond (1991), was utilized. The GMM approach enhances the consistency of the estimates by controlling for potential simultaneity and measurement errors in the explanatory variables.

Model estimations were conducted in two stages: first, the difference GMM was applied, followed by the system GMM to enhance the efficiency of the estimates. System GMM allows for unbiased and efficient estimations by using both level and difference equations. The stationarity of the series was assessed with k-CIPS panel unit root tests. Non-stationary series were made stationary by taking their first differences and were included in the analysis.

This model structure enables the evaluation of factors influencing economic growth in BRICS countries by accounting for both within-country dynamics (within-country effects) and between-country differences (between-country effects). Consequently, the short-term and long-term effects of key macroeconomic variables such as transportation services, exports, energy consumption, and industrial production on economic growth were empirically tested.

3.3. Econometric Properties of Variables and Test Results

In dynamic panel data analysis, the validity of the model hinges on accurately determining the econometric properties of the variables used. Therefore, key statistical properties such as the degree of stationarity of the series, autocorrelation, and cross-sectional dependence were examined first.

3.4. Panel Unit Root Tests

In econometric analyses, the stationarity of time series has a direct impact on the reliability of estimation results. To this end, the Levin-Lin-Chu (LLC) and Im-Pesaran-Shin (IPS) panel unit root tests were applied to annual data for the BRICS countries. The LLC test assumes a common autocorrelation structure in the panel, while the IPS test accounts for individual country variability. Results from both tests indicate that some variables are non-stationary at their level values, but the stationarity condition is met when their first differences are considered.

Based on these findings, the variables for economic growth (GDP), exports (EXG), transportation services (TRS), renewable energy consumption (RNC), and industrial production (NDS) are all stationary at level I(1). Thus, panel cointegration analysis can be performed to assess the existence of a long-term equilibrium relationship among the series.

3.5. Cross-Section Dependence and Autocorrelation

In panel data analyses, cross-sectional dependence often exists among observations due to the economic relationships between countries. This study examined cross-sectional dependence using the Pesaran (2004) CD test, which showed significant cross-sectional dependence between the series. This finding confirms that the economic structures and foreign trade ties of the BRICS countries are highly integrated.

Furthermore, the Arellano-Bond autocorrelation tests (AR[1] and AR[2]) were applied to determine whether the error terms in the model contained autocorrelation. The significant results of the AR(1) test, along with the insignificant results of the AR(2) test, support the model's suitability for autocorrelation and the reliability of the GMM estimation results.

3.6. Cointegration Analysis and Causality Structure

The Pedroni (1999) and Kao (1999) panel cointegration tests were utilized to determine the existence of a long-term equilibrium relationship between the series. The test results revealed a long-term cointegration relationship among the variables in the model. This indicates that economic growth is statistically significantly influenced by factors such as transportation, energy, exports, and industrial production in the long-term.

Short- and long-term causality relationships were tested using the vector error correction model (VECM). The findings showed

a unidirectional causality running from transportation services and energy consumption to growth in the short-term. In contrast, in the long-term, there were reciprocal (bidirectional) causality relationships among the variables.

3.7. Model Fit Tests

The validity of the estimated GMM model was assessed using the Sargan and Hansen over-identification tests. The results of both tests indicated that the instrumental variables used in the model were valid and that there was no over-identification problem. Thus, the statistical reliability of the model was confirmed.

4. DATA AND FINDINGS

The BRICS countries exhibit similar economic processes due to their economic and social agreements. As a result, the factors affecting economic growth are expected to have similar effects across all member countries. In this study, the following macroeconomic determinants of economic growth were examined: Goods and services exports, the industrial production index, renewable energy consumption, and transportation services. Exports of goods and services were included in the model as a percentage of economic growth, and renewable energy consumption was measured as a share of total energy consumption. Economic growth was represented as a percentage of annual growth. A summary of the model variables and their definitions is provided in Table 1. The annual data used in the study covers the period from 1994 to 2023, with all variables sourced from the World Bank databases at https://data.worldbank.org (Accessed on September 1, 2025).

Table 2 presents descriptive statistics for the economic growth rates of the BRICS countries. The average values indicate that China had the highest growth rate at 8.59%, while Russia had the lowest at 2.05%. This suggests that China demonstrated stable and high performance during the analysis period, whereas Russia was more vulnerable to external shocks. The standard deviation values were particularly high in Russia and India, indicating that economic growth in these countries was subject to cyclical fluctuations. A generally negative skewness coefficient suggests a left-skewed distribution of growth rates, while kurtosis coefficients above 3 indicate the presence of outliers in the series. On average (4.35%), growth in the BRICS countries was positive and moderate. These findings highlight the structural differences among countries, suggesting that country-specific effects should be considered in panel data analysis.

Graph 1 illustrates the economic growth rates of the BRICS countries over the years. The graph reveals significant differences among countries. While China's growth has consistently followed a high and stable trend, India has shown a recovery trend following the 2008 crisis. In Russia, sharp declines were observed, particularly after 2014. Brazil and South Africa displayed fluctuating growth rates. Overall, the growth trends of these countries have converged since 2010, indicating a strengthening of economic integration within BRICS.

Table 3 presents descriptive statistics for the export growth rates of the BRICS countries. The average values indicate that Russia experienced the highest export growth at 30.33%, while Brazil had the lowest at 12.67%. This disparity reflects Russia's strong foreign trade performance, primarily driven by energy and raw material exports during the analysis period. The high standard deviation values, especially for China (5.57) and Russia (5.04), suggest that exports in these countries are highly susceptible to cyclical fluctuations. The generally positive skewness coefficients indicate a right-skewed distribution, meaning that higher values appear more frequently. Moreover, kurtosis coefficients around 3 suggest that the data are close to a normal distribution. Overall, with an average export growth of 22.16%, foreign trade dynamics are a key determinant of economic growth in the BRICS countries.

Graph 2 illustrates the changes in export growth rates of the BRICS countries over time. It reveals that China and Russia exhibited high and stable export performance, while Brazil and India followed a more volatile trajectory. Following the 2008 global crisis, all countries experienced a short-term decline, but recovery became evident in subsequent years. China's export trend appears to be stronger than that of other countries, underscoring its significant role in global production chains. Overall, the graph indicates a long-term upward trend in exports across BRICS countries, despite growth disparities, with foreign trade volumes continuing to increase.

Table 1: Research variables and sources

Code	Country	Variable	Description	Source
BRA	Brazil	EXG	Exports of goods and services (% of GDP)	https://data.worldbank.org
CHN	China	NDS	Industry (including construction)	https://data.worldbank.org
IND	India	RNC	Renewable energy consumption (% of total final energy consumption)	https://data.worldbank.org
RUS	Russia	TRS	Transport services (% of commercial service exports)	https://data.worldbank.org
ZAF	South Africa	GDP	GDP growth (annual %)	https://data.worldbank.org

Table 2: Descriptive statistics for GDP

Country	Mean	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis
BRA	2.4090	2.9567	7.5282	−3.5458	2.7205	−0.5344	3.0587
CHN	8.5944	8.4693	14.2309	2.2386	2.6377	−0.2362	3.4433
IND	6.3042	7.1986	9.6896	−5.7777	2.8575	−2.6220	11.6827
RUS	2.0563	3.2036	10.0001	−12.5698	5.2171	−0.8800	3.4468
ZAF	2.3653	2.6500	5.6038	−6.1689	2.3329	−1.5993	7.1653
All	4.3458	4.4440	14.2309	−12.5698	4.2128	−0.7426	4.4009

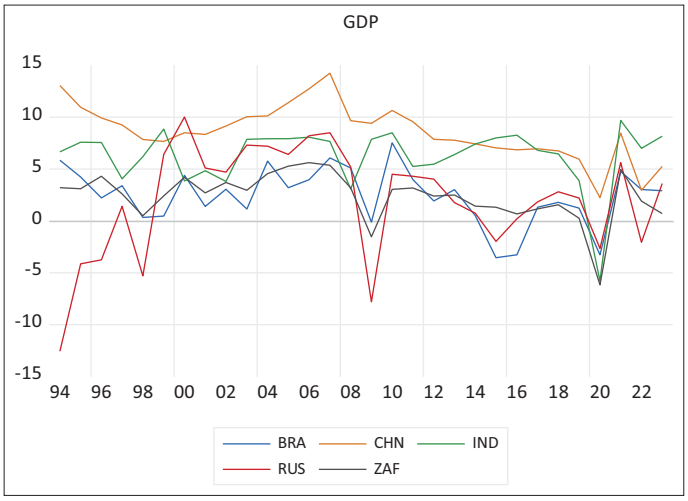
Table 3: Descriptive statistics for EXG

Country	Mean	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis
BRA	12.6742	12.4928	19.6308	6.7302	3.4144	0.1077	2.5596
CHN	23.3176	20.8426	36.0352	17.9232	5.5719	1.0411	2.8666
IND	18.1479	19.3817	25.4309	9.8881	4.9458	−0.3780	1.8029
RUS	30.3294	28.9595	44.0604	23.0830	5.0406	1.1864	4.0492
ZAF	26.3095	27.1706	33.3715	19.5493	3.5751	0.0329	2.4839
All	22.1557	22.3351	44.0604	6.7302	7.6836	0.1052	2.6547

Table 4: Descriptive statistics for NDS

Country	Mean	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis
BRA	22.3047	22.4177	35.4209	18.1885	3.0292	2.5253	12.9764
CHN	43.2362	44.9692	46.8865	36.7725	3.5008	−0.7217	1.8902
IND	27.9228	27.6423	31.1367	24.5915	1.8972	0.2637	2.1244
RUS	31.5757	31.4621	41.2153	27.9315	2.7334	1.4494	6.1697
ZAF	26.1476	25.2990	31.2303	23.3394	2.3191	0.7119	2.3732
All	30.2374	28.5188	46.8865	18.1885	7.6727	0.8436	2.7454

Graph 1: Time path graph for gross domestic product



Graph 2: Time path graph for exports

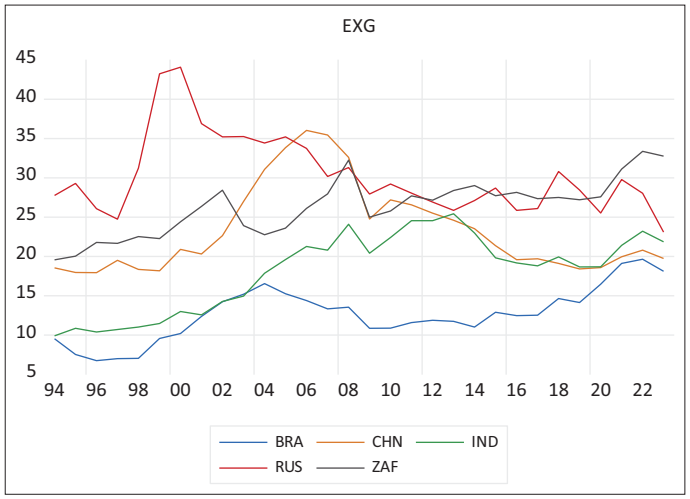
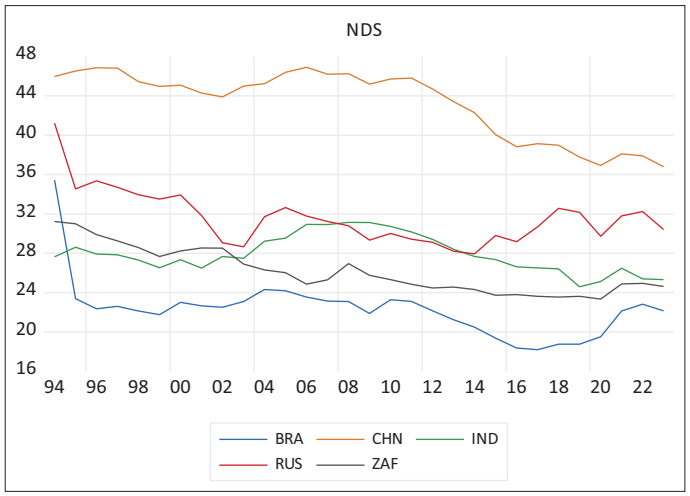


Table 4 provides descriptive statistics regarding the industrial production rates of BRICS countries. The average values show that China had the highest industrial production at 43.24%, while Brazil had the lowest at 22.30%. This highlights the strength of China's production-based economic structure and its capacity for industrialization, whereas Brazil's manufacturing sector has seen more limited growth. Standard deviation values vary across countries, with particularly high volatility in production rates observed in China and Russia. Positive skewness coefficients and kurtosis coefficients close to 3 indicate that the series is nearly normally distributed but contains extreme values during certain periods. The overall average of 30.24% suggests that industrial production in the BRICS countries remained high throughout the analysis period and served as one of the main drivers of economic growth.

Graph 3: Time path graph for NDS



Graph 3 depicts the trajectory of industrial production in the BRICS countries over time. It clearly demonstrates a steady increase in China's production capacity. In contrast, India and Russia show moderate but fluctuating production rates, while Brazil and South Africa have limited production that is more susceptible to periodic shocks. While all countries experienced a short-term slowdown after 2008, production volumes —particularly in China and India— recovered rapidly. Overall, the graph indicates that industrial production in the BRICS countries has maintained a positive long-term trend, with the industrial sector being central to economic growth.

Table 5 offers descriptive statistics for renewable energy consumption rates in BRICS countries. According to the average values, Brazil has the highest share of renewable energy at 45.48%, while Russia has the lowest at 3.49%. This illustrates Brazil's strong energy structure based on hydropower and biofuel resources, while Russia relies heavily on a fossil fuel-dependent energy system. India's notable renewable energy consumption level, averaging 40.31%, reflects the effectiveness of its policies aimed at increasing energy diversity. High standard deviation values in China and India indicate that renewable energy consumption in these countries is sensitive to seasonal fluctuations. Positive skewness coefficients suggest that the series are distributed to the right, and kurtosis coefficients below 3 imply that the distribution is flatter than normal. The overall average of 23.93% indicates that while the share of renewable energy is rising in BRICS countries, significant differences exist between them.

Graph 4 illustrates the trend of renewable energy consumption in the BRICS countries over time. The graph indicates that Brazil and India maintain a high and stable level of renewable energy use. Meanwhile, China's consumption is on the rise, with a noticeable acceleration in its transition to renewable energy in recent years. South Africa shows a gradual but fluctuating increase, while Russia demonstrates a low and steady pattern of renewable energy consumption. This variation highlights that energy policies within the BRICS countries are at different stages of development, resulting in varying speeds of energy transitions across these nations. Overall, the graph indicates a general upward trend in renewable energy consumption throughout the analysis period, particularly pronounced in China, India, and Brazil.

Graph 4: Time path graph for renewable energy consumption

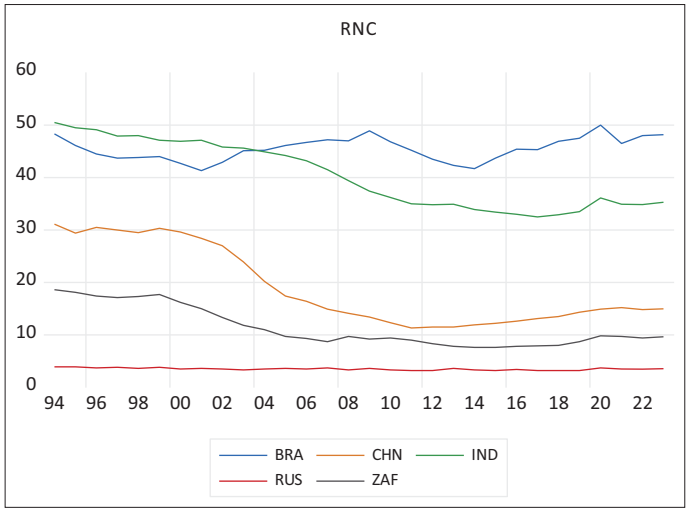


Table 6 presents the descriptive statistics for transportation services in BRICS countries. The average values reveal that Russia has the highest transportation activity rate at 31.96%, while India has the lowest at 13.96%. This disparity reflects Russia's vast geography and the significant share of energy transportation infrastructure in its sector, in contrast to India's constrained transportation infrastructure. The high standard deviation values, particularly for China and Brazil, indicate that transportation activities in these countries are subject to cyclical fluctuations. The predominantly positive skewness coefficients show that the distribution exhibits a right-skewed nature, suggesting that high growth rates are more commonly observed. The kurtosis coefficients, which are close to 3, indicate that the data approximates a normal distribution. The overall mean stands at 19.94%, suggesting a steady increase in transportation services as a driver of growth in the BRICS economies.

Graph 5 depicts the development of transportation services in the BRICS countries over the years. The trends across the countries are diverse. Russia's transportation activities have remained high throughout the period, reflecting the importance of energy exports and logistics infrastructure. China shows a continuous growth trend in its transportation sector, while Brazil and South Africa exhibit notable periodic fluctuations. Despite starting from a lower level, India has shown a steady growth trend in transportation services. Overall, the graph indicates that transportation services in the BRICS countries have expanded over time and contributed significantly to economic growth and production activities.

Table 7 displays the correlation coefficients among key variables for BRICS countries. The findings reveal a positive and

Table 5: Descriptive statistics for RNC

Country	Mean	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis
BRA	45.4822	45.3500	50.0000	41.3000	2.2197	−0.0364	2.2282
CHN	19.0056	14.9333	31.1000	11.3000	7.4834	0.6123	1.6204
IND	40.3104	38.4000	50.5000	32.5000	6.2778	0.2174	1.3923
RUS	3.4941	3.5000	3.9000	3.2000	0.2184	0.1371	2.0148
ZAF	11.3578	9.6667	18.6000	7.6000	3.8045	0.8403	2.0697
All	23.9300	17.4000	50.5000	3.2000	17.0498	0.2019	1.4083

Table 6: Descriptive statistics for TRS

Country	Mean	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis
BRA	17.6538	15.0568	45.6716	11.3642	8.3327	2.4299	8.0950
CHN	17.4993	18.0142	39.5179	3.6663	8.6618	0.4404	3.7588
IND	13.9554	12.1963	28.4221	8.7170	5.4267	1.7760	5.1390
RUS	31.9644	31.7890	45.8543	25.3536	4.2228	0.8841	5.0334
ZAF	18.6413	18.4291	25.8924	12.0207	3.7446	0.1427	2.2809
All	19.9428	17.7909	45.8543	3.6663	8.8860	0.7218	2.9949

Graph 5: Time path graph for transportation services

moderate relationship between economic growth and industrial production (r = 0.503), highlighting that production activities significantly influence growth. In contrast, there is a negative relationship between economic growth and transportation services (r = −0.2269), suggesting that fluctuations in the transportation sector have a limited short-term impact on growth. Additionally, a strong negative relationship (r = −0.8307) was found between exports and renewable energy consumption, indicating that countries with high export levels tend to rely more on fossil fuels. Conversely, the positive relationship between industrial production and exports (r = 0.3404) indicates that increased production bolsters foreign trade volume. Overall, the correlation results illustrate that the interactions among economic growth, energy, and trade within the BRICS countries are multifaceted and complementary.

The findings related to cross-sectional dependence and stationarity for the variables included in the study are presented in Table 8. Cross-sectional dependence was examined using the Breusch-Pagan LM test, and the probability values (Prob. = 0.0000) for all variables fell below the 1% significance level. This result indicates a strong cross-sectional dependence among the BRICS countries in the panel, reflecting a high level of economic interactions between them. Stationarity was assessed using the CIPS (Cross-Sectionally Augmented IPS) method, which is a second-generation unit root test that accounts for cross-sectional dependence. The CIPS test results showed that all variables (GDP, EXG, NDS, RNC, and TRS) were stationary at the level (P < 0.01). This finding suggests that the mean and variance of the variables remained consistent over time, despite the presence of common shocks in the series. The stationarity of the series related to economic growth, exports, industrial production, renewable energy consumption, and transportation services in the BRICS countries mitigates the risk of spurious regression in panel data analysis and enhances the reliability of model estimates.

Table 9 presents the analysis results related to the research model. The Hausman test results ($\chi^2 = 3.2445$; P = 0.51078) indicate that the random effects approach is suitable for the model. The findings reveal that the variables of exports (EXG), industrial production

Table 7: Correlation coefficients for research variables

Variable	GDP	EXG	NDS	RNC	TRS
GDP	1.0000	0.0602	0.5030	0.1363	−0.2269
EXG	0.0602	1.0000	0.3404	−0.8307	0.3060
NDS	0.5030	0.3404	1.0000	−0.3473	0.1030
RNC	0.1363	−0.8307	−0.3473	1.0000	−0.4835
TRS	−0.2269	0.3060	0.1030	−0.4835	1.0000

Table 8: Cross-sectional dependence and unit root test findings for research data

Variable	Cross-section dependence		CIPS unit root test (level)	
	Statistic	Probability	Statistic	Probability
GDP	70.0534	0.0000	−4.1916	<0.01
EXG	57.9506	0.0000	−3.7816	<0.01
NDS	84.0063	0.0000	−4.4223	<0.01
RNC	127.3172	0.0000	−3.0034	<0.01
TRS	67.7877	0.0000	−4.7769	<0.01

Table 9: Research model analysis findings

Variable	Coefficient	Standard error	t- statistic	Probability
EXG	0.30788	0.073763	4.173925	0.0001
NDS	0.247174	0.082305	3.003156	0.0032
RNC	0.185315	0.04743	3.907143	0.0001
TRS	0.063884	0.048235	1.324449	0.1875
C	−15.55187	3.597245	−4.323273	0.0000
Hausman testi: chi2 (4) =3.2445; P=0.51078				
R-squared		0.2379		
Adjusted R-squared		0.2162		
Durbin-Watson stat		1.7279		
J-statistic	0.0000	Instrument rank		5

(NDS), and renewable energy consumption (RNC) have positive and statistically significant effects on economic growth (P < 0.01). In contrast, the effect of transportation services (TRS) is positive but not statistically significant (P > 0.05). The adjusted R^2 value of the model is 0.2162, meaning that the explanatory variables account for approximately 22% of the variance in economic growth. Furthermore, the Durbin-Watson statistic (1.7279) indicates no autocorrelation problem in the model. Overall, the findings suggest a positive correlation between economic growth in the BRICS countries and exports, production, and renewable energy consumption.

Cross-sectional effects by country are detailed in Table 10. The findings indicate negative country effects for Brazil (−0.8819) and Russia (−1.4809), while positive effects are observed for China (1.3977), India (0.9075), and South Africa (0.0575). This suggests that the constant term estimates in the model vary across countries. Negative effect values indicate that the baseline economic growth in Brazil and Russia is lower than the overall average predicted by the model. Conversely, the positive effects for China and India suggest that their economic performance exceeds the model average and that foreign trade, production, and energy indicators strongly support growth in these countries. Thus, the direction and magnitude of country effects among BRICS nations reveal differences in their economic structures. Consideration of these

Table 10: Cross-sectional effects according to the research model

Country	Effect
BRA	−0.8819
CHN	1.397739
IND	0.907541
RUS	−1.480891
ZAF	0.057511

country-fixed data in panel data analysis enhances the explanatory power of the model.

5. CONCLUSION AND RECOMMENDATIONS

This study investigates the interactions between transportation services, exports, renewable energy consumption, industrial production, and economic growth in BRICS countries, utilizing data from 1994 to 2023 within a dynamic panel data analysis framework. The findings indicate that exports, industrial production, and renewable energy consumption are key determinants of economic growth, with positive and statistically significant effects. This implies that an increase in production capacity contributes to a larger foreign trade volume, and the transition to renewable energy aligns with economic growth trends. However, although the effect of transportation services on economic growth is positive, it is not statistically significant, suggesting that the impact of transportation infrastructure on growth operates through indirect and long-term mechanisms.

The analysis of country-fixed effects reveals that China and India have positive effects that exceed the model average, while Brazil and Russia show negative effects. This divergence highlights the structural differences in economic structures, energy supply security, foreign trade policies, and industrial production strategies among the BRICS countries. Correlation analysis further supports this conclusion; the positive relationship between industrial production and exports validates the production-driven growth hypothesis. Additionally, it shows that renewable energy consumption acts as a balancing factor between economic growth and environmental sustainability.

Based on these findings, to achieve sustainable growth targets in the BRICS countries, it is recommended to increase investments in renewable energy, expand digital transformation and green technologies in industrial production, and enhance the sectoral diversification of foreign trade. Moreover, developing green logistics practices and energy-efficient transportation infrastructure will not only accelerate economic growth but also improve environmental performance by reducing carbon intensity.

The research indicates that long-term development in the BRICS nations is attainable only through a growth model based on renewable energy, with a focus on production and foreign trade. Addressing energy supply security, production efficiency, and trade capacity in a coordinated manner will be crucial for enhancing economic resilience and aligning with global sustainability goals.

REFERENCES

Abdibekov, S.U., Gridneva, Y.E., Kaliakparova, G.S., Amankeldi, N.A., Perneyeva, G.A., Kulbay, B.S., Myrzabekkyzy, K. (2024), The relationship between energy consumption, agricultural and industrial production, and economic growth: ARDL border value approach in the case of Kazakhstan. International Journal of Energy Economics and Policy, 14(3), 79-86.

Aidarova, A.B., Mukhamediyeva, G., Yessentayeva, A.A., Utemissova, G., Tastanbekova, K., Mustafayeva, B., Myrzabekkyzy, K. (2024), Relationship between oil exports, renewable energy consumption, agriculture industry, and economic growth in selected OPEC countries: A panel ARDL analysis. International Journal of Energy Economics and Policy, 14(6), 344-352.

Aldakhil, A.M., Nassani, A.A., Awan, U., Abro, M.M.Q., Zaman, K. (2018), Determinants of green logistics in BRICS countries: An integrated supply chain model for green business. Journal of Cleaner Production, 195, 861-868.

Andre, C., Balcilar, M., Chang, T., Gil-Alana, L.A., Gupta, R. (2018), Current account sustainability in G7 and BRICS: Evidence from a long-memory model with structural breaks. The Journal of International Trade and Economic Development, 27(6), 638-654.

Anser, M.K., Ali, S., Umair, M., Javid, R., Mirzaliev, S. (2024), Energy consumption, technological innovation, and economic growth in BRICS: A GMM panel VAR framework analysis. Energy Strategy Reviews, 56, 101587.

Arellano, M., Bond, S. (1991), Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. The Review of Economic Studies, 58(2), 277-297.

Available from: https://data.worldbank.org [Last accessed on 2025 Sep 01].

Avritzer, L. (2019), The double crisis of representation and participation in Brazil. Representation, 55(3), 251-263.

Baimagambetova, L., Baibulekova, L., Aliyeva, Z.T., Aidarova, A.B., Mashirova, T., Balapanova, E., Nurpeissova, A., Bolganbayev, A. (2025), Analysis of the effects of energy consumption, employment, mining, natural resource ıncome, and foreign direct ınvestments on economic growth in the central Asian Turkic republics using panel causality tests. International Journal of Energy Economics and Policy, 15(3), 204-213.

Bhattacharya, M., Bhattacharya, S.N. (2016), International trade and economic growth: Evidences from the BRICS. Journal of Applied Economics and Business Research, 6(2), 150-160.

BRICS II Summit. (2010), Joint Statement. Available from: https://www.unaoc.org/docs/II-brıc-summit.pdf [Last accessed on 2025 Sep 05].

Chandrasekaran, S.J. (2024), Agricultural value added in BRICS: A panel data study. International Journal of Energy Economics and Policy, 14(3), 171-178.

Chang, C.L., Fang, M. (2022), Renewable energy-led growth hypothesis: New insights from BRICS and N-11 economies. Renewable Energy, 188, 788-800.

Chhabra, M., Giri, A.K., Kumar, A. (2023), What shapes economic growth in BRICS? Exploring the role of institutional quality and trade openness. Economic Papers: A Journal of Applied Economics and Policy, 42(4), 347-365.

Cook, N. (2013), South Africa: Politics, economy, and U.S. Relations (CRS Report No. R43130). Congressional Research Service. Available from: https://sgp.fas.org/crs/row/R43130.pdf [Last accessed on 2025 Sep 04].

Haqqani, H. (2014), India and the Global Economy: A Collection of Essays Presented at the Hudson Institute-Observer Research Foundation Roundtable on "India's Economic Engagements with the world. New Delhi, India. Washington, DC: Hudson Institute. Available from:

https://www.hudson.org/sites/default/files/researchattachments/attachment/1420/indiaandthe_global_economy_hudson.pdf [Last accessed on 2025 Sep 04].

Jash, A. (2017), The emerging role of BRICS in the Changing World Order. IndraStra Global, 6, 1-11.

Kao, C. (1999), Spurious regression and residual-based tests for cointegration in panel data. Journal of Econometrics, 90(1), 1-44.

Kumar, S., Shahid, A., Agarwal, M. (2024), Is BRICS expansion significant for global trade and GDP?. BRICS Journal of Economics, 5(4), 5-36.

Kutu, A.A., Ngalawa, H. (2016), Dynamics of industrial production in BRICS countries. International Journal of Economics and Finance Studies, 8(1), 1-25.

Lucas, R.E. Jr. (1988), On the mechanics of economic development. Journal of Monetary Economics, 22(1), 3-42.

Lukhmanova, G., Urazymbetov, B., Sarsenova, A., Zaitenova, N., Seitova, V., Baisholanova, K., Bolganbayev, A. (2025), Investigating the relationship between energy consumption and economic growth using toda-yamamoto causality test: The case of Kazakhstan and Azerbaijan. International Journal of Energy Economics and Policy, 15(1), 374-383.

Malik, A., Bansal, R., Soomro, M.H. (2023), Does FDI impact the economic growth of BRICS economies? Evidence from Bayesian VAR. Journal of Risk and Financial Management, 17(1), 10.

Mau, V. (2018), Russian economic policy: Challenges of growth. Russian Journal of Economics, (4), 87-107.

Morrison, W.M. (2019), China's Economic Rise: History, Trends, Challenges, and İmplications for the United States (CRS Report No. RL33534). Congressional Research Service. Available from: https://crsreports.congress.gov/product/pdf/RL/RL33534 [Last accessed on 2025 Sep 05].

O'Neill, J. (2001), Building better global economic BRICs. Goldman Sachs, Global Economics Papers, (66), 1-16.

Pedroni, P. (1999), Critical values for cointegration tests in heterogeneous panels with multiple regressors. Oxford Bulletin of Economics and Statistics, 61(S1), 653-670.

Pesaran, M.H. (2004), General Diagnostic Tests for Cross Section Dependence in Panels. CESifo Working Papers No.1233.

Rasool, H., Maqbool, S., Tarique, M. (2021), The relationship between tourism and economic growth among BRICS countries: A panel cointegration analysis. Future Business Journal, 7(1), 1-11.

Romer, P.M. (1990), Endogenous technological change. Journal of Political Economy, 98(5, Part 2), 71-102.

Simo-Kengne, B.D., Bitterhout, S. (2023), Corruption's effect on BRICS countries' economic growth: A panel data analysis. Journal of Economics, Finance and Administrative Science, 28(56), 257-272.

Thussu, D. (2018), BRI: Bridging or breaking BRICS?. Global Media and China, 3(2), 117-122.