Dynamics of Economic Growth in BRICS Countries: The Relationship between Non-Fossil Energy Consumption, Agricultural Exports, and Technological Innovation

AHSANAL HUDA[1,*], ANTON BAWONO[2], MUHAMMAD IQBAL[3],
WAN RUSLAN ABDUL GHANI[4], KHAVID NORMASYHURI[5]
[1]Postgraduate Program,
State Islamic University of Raden Intan Lampung,
INDONESIA

[2]Faculty of Islamic Economics and Business
State Islamic University of Kalijaga Yogyakarta,
INDONESIA

[3]Faculty of Islamic Economics and Business
State Islamic University of Raden Intan Lampung,
INDONESIA

[4]East Lampung Regency Transportation Agency
INDONESIA

[5]Faculty of Economics and Business,
University of Lampung,
INDONESIA

**Corresponding Author*

Abstract: - This study examines the short- and long-run effects of non-fossil energy consumption, agricultural exports, and technological innovation on economic growth in BRICS countries. Using annual secondary data for Brazil, Russia, India, China, South Africa, Indonesia, Egypt, Iran, Ethiopia, and the United Arab Emirates from 2004 to 2023, sourced from the World Bank, IEA, UNCTAD, and OECD. The analysis applies a dynamic panel Generalized Method of Moments (GMM) model estimated in Stata 17. The findings indicate that non-fossil energy consumption has a positive and significant effect on economic growth in both the short and long run. Agricultural exports also have a positive and significant effect on economic growth in both the short and long run. Similarly, technological innovation has a positive and significant effect on economic growth in both the short and long run. These results highlight the importance of accelerating the transition toward non-fossil energy, strengthening agricultural exports, and promoting technological innovation to sustain economic growth in BRICS countries.

Key-Words: - Non-Fossil Energy Consumption, Agricultural Exports, Technological Innovation, Economic Growth, Keynesian Theory, Generalized Method of Moments (GMM).

Received: September 14, 2026. Revised: October 5, 2026. Accepted: October 19, 2026. Published: November 26, 2026.

1 Introduction

Economic growth is something that people always talk about when they study economics. It is an important sign of how well a country is doing economically. A long time ago, [1] and [2] said that markets can fix themselves and find a balance. Economic growth remains relevant today because classical economic theories continue to explain economic growth and how markets work. However, [3] proposed the idea that markets do not always operate independently to achieve equilibrium. Economic growth continues to be a subject of study in the field of development economics.

The economic growth of developing countries requires careful monitoring. The BRICS coalition, which includes Brazil, Russia, India, China, South Africa, Indonesia, Egypt, Iran, Ethiopia and the United Arab Emirates, is really important. BRICS countries are becoming more powerful. They can really change the way the global economy works. The main goal of the BRICS countries is to be able to take care of themselves and not have to rely on countries for money. This is very important for the BRICS countries, such as Brazil, Russia, India, China, South Africa, Indonesia, Egypt, Iran, Ethiopia, and the United Arab Emirates, because it helps them grow and be more independent, which is what the BRICS countries are trying to do. The BRICS countries want to be able to make their decisions and not have to depend on other countries that is why the BRICS coalition is working towards this goal.

The World Bank has some data from 2004 to 2023. The World Bank member countries, like the BRICS countries have seen a lot of ups and downs in their development. Brazil is an example of this. It had an economic growth rate of 2.31 percent. The BRICS countries did a lot better than Brazil. The BRICS countries had a growth rate of 4.68 percent. This is a difference, from Brazil's growth rate. The economic growth of the BRICS countries is really something to look at. The World Bank member countries, including the BRICS countries have a lot to learn from each other. Brazil's economy has had some difficult years, and it has also contracted occasionally. Brazil experienced a difficult period, with its economy contracting by -3.54 percent in 2015.

Russia has an economic growth rate of 2.70 percent. Russia's economic growth rate is very slow. It is much slower than the growth rate of countries like Brazil, China, India, and South Africa. The BRICS countries are doing better than Russia when it comes to economic growth. Russia's economic growth rate is not as good as the BRICS countries economic growth rate. The BRICS countries are doing a lot better-than Russia when it comes to growth rate. The Russian economy has had several difficult years. In 2009, Russia's economic growth was-7.90 percent due to very high structural dependence on fossil fuel exports. India has an average economic growth rate of 6.48 percent, significantly higher than the BRICS countries.

India's economic growth in 2010 was high at 8.50 percent, driven by a combination of technological innovation. China had an average economic growth rate of 8.18 percent, significantly higher than the BRICS countries. China's economic growth in 2007 was high at 14.15 percent, a combination of an export boom and the beginning of technological transformation. South Africa did not do well with its economy. The country had an economic growth rate of 2.07 percent. This is lower than the average for South Africa and other BRICS countries. South Africa had a tough time with its economy in 2009. The economy of South Africa actually shrank by -1.54 percent. This happened because of the financial problems that affected the whole world in 2008 and 2009. The financial crisis had an impact on South Africa. Then South Africa had its problems with energy, which made things even worse, for the economy of South Africa.

Indonesia has an average economic growth rate of 4.97 percent and is slightly higher than the average of BRICS member countries of 4.68 percent. Indonesia's high economic growth in 2007 of 6.35 percent was driven by a combination of commodity exports, especially agricultural commodities, and strong household consumption. Egypt has an average economic growth rate of 4.48 percent and is slightly lower than the average of BRICS member countries of 4.68 percent. Egypt experienced a difficult period in 2011, with its economy contracting by 1.76 percent due to the political crisis and security instability following the January 25, 2011 Revolution, which had a very real negative impact on sectors that support economic growth, namely energy and agricultural exports, and greatly hampered technological innovation.

Ethiopia has a good economy. The country of Ethiopia is growing at a rate of 9.43 percent on average. This is a good number, for Ethiopia. Ethiopia is doing well with an economic growth rate of 9.43 percent. This is much higher than the BRICS countries. Ethiopia's high economic growth in 2004 of 13.57 percent was driven primarily by agricultural exports supported by massive public investment and agricultural productivity. The United Arab Emirates (UAE) had an average economic growth rate of 3.51 percent which was lower than the BRICS average of 4.68 percent. The UAE experienced a difficult period with its economy in 2009 at -5.24 percent due to the continued impact of the 2008 global financial crisis and the decline in global fossil fuel prices due to the crisis also contributed to the decline in overall state revenue.

From a Keynesian perspective, expenditure is crucial for economic growth because aggregate consumption influences national income and output. Non-fossil fuel consumption represents a segment of expenditure that facilitates economic activity through more sustainable energy sources. Numerous studies have shown that non-fossil fuel consumption

can serve as a driver of growth, particularly in high-income countries with adequate technology, infrastructure, and investment capabilities [4], [5]. However, alternative research suggests that non-fossil fuel use can have a negative or negligible impact on economic growth. This distinction highlights that the impact of non-fossil fuel use is not inherent, but rather depends on technological readiness, infrastructure adequacy, and a country's ability to finance initial investment expenditures [6], [7].

Agricultural exports are really important for the economy. They help by making more people in countries want to buy the food we grow and the things we make from it. When we sell more of these things to countries it does a few good things for us. It helps us get money from other countries, which is called foreign exchange earnings. It also helps the people who grow food and make things from it because they can sell more of their stuff. This gives the agricultural sector money, and that helps the whole economy. It even helps all the people who work with food and farm products, like the people who process and transport them, because it creates more work for them to do. Agricultural exports are very good for the sector, and they help make the economy stronger. Several studies have shown that agricultural exports contribute positively to economic growth because this sector is able to connect domestic production capacity with international market demand [8], [9].

Empirical findings regarding the relationship between agricultural exports and economic growth are not entirely consistent. Several studies indicate that agricultural exports have no significant impact on economic development in low-income countries, either in the short or long term. This condition can occur due to low agricultural productivity, technological limitations, weak commodity value-added, dependence on raw material exports, and low competitiveness in the global market. The contribution of agricultural exports to economic growth depends on production capacity, commodity quality, added value, and a country's ability to integrate the agricultural sector into international trade [10], [11].

From a Keynesian perspective, technological innovation is a component of investment spending, which drives economic expansion by increasing aggregate demand. Increased technology spending by firms or governments increases demand for capital goods, production equipment, labor, and supporting services. Increased investment spending raises the incomes of economic actors, increases production activity, and generates a multiplier effect on national output. Technological innovation not only signals technological progress but also serves as a vehicle for investment, increasing national demand, income, and production [12], [13].

Empirical evidence on the impact of technological innovation on economic growth is not entirely consistent. Many studies show that technological innovation has a positive effect on economic growth when investment spending increases national income, productivity, and output. Conversely, other studies suggest that technological innovation may have negligible or detrimental effects in the short run due to the large initial investment costs and gradual realization of economic benefits. The impact of technological innovation on economic growth depends on the effectiveness of investment spending in stimulating aggregate demand and increasing national output [14], [15].

A recognized research gap relates to the theoretical foundations of previous studies, which have largely centered on neoclassical economic growth theory and the classical Cobb-Douglas production function, which exclusively considers capital, labor, and consumption as the main factors influencing economic growth [16], [17]. In contrast, other studies use Keynesian growth theory, which states that aggregate spending can stimulate economic growth [18].

From a geographical perspective, a clear research gap is evident due to limited regional coverage. Previous studies have focused solely on the G7 countries during the period 1980 to 2016—the United States, the United Kingdom, Germany, Japan, France, Italy, and Canada. These studies are limited to the context of developed countries and do not examine developments outside that regional environment [19], [20]. This gap is important to acknowledge, as it neglects developing countries, particularly those within the BRICS alliance. Further methodological gaps indicate that previous studies continue to use Ordinary Least Squares (OLS) techniques to assess relationships between variables and Analysis of Variance (ANOVA), both of which are essentially based on linear analysis or basic regression approaches [21], [22]. The Generalized Method of Moments (GMM) analytical model, designed by Blundell and Bond (1998), was used in this study. This model is highly adept at handling heteroscedasticity, autocorrelation, and non-linearity in the data.

The urgency of this research lies in BRICS's position as a group of developing economies with a strategic role in driving economic growth, food security, and the global energy transition. Non-fossil

energy consumption is crucial because it can reduce dependence on fossil fuels, reduce energy expenditure, and strengthen aggregate demand. Agricultural exports also play a crucial role because they are related to increasing foreign exchange, expanding food commodity markets, and strengthening global food security. Technological innovation is needed to increase investment effectiveness, improve production efficiency, and strengthen economic capacity to respond to structural changes [23], [24], [25]. Data from the World Bank and the International Energy Agency (IEA) shows that the average non-fossil energy consumption of BRICS member countries from 2004 to 2023 was only around 24.06 percent. This situation indicates that the energy transition in BRICS is not yet optimal, while the region's economic growth is increasingly dependent on the ability to integrate non-fossil energy consumption, agricultural exports, and technological innovation more effectively.

Further studies show that agricultural exports contribute to strengthening industrial competitiveness, increasing foreign exchange earnings, and driving economic growth through increasing exports of agricultural products with added value [26], [27]. UNCTAD data shows that the average contribution of BRICS countries' agricultural exports from 2004 to 2023 was approximately 2.52 percent. Furthermore, technological innovation plays a crucial role in creating a favorable investment climate, increasing production efficiency, and accelerating economic growth [28], [29]. World Bank data shows that the average contribution of technological innovation in BRICS countries is only around 1.5 percent, indicating that technological potential has not been fully utilized to drive economic growth.

2 Literature Review

2.1 Keynesian Theory of Economic Growth

John Maynard Keynes in 1936 said that economic activity happens because of demand. This total demand comes from people spending money businesses investing, the government spending, and selling more than buying from countries. This happens especially when the normal way the market works can't keep production and jobs at a level. On the other hand, the neoclassical economic growth theory that Robert Solow created in 1956 explains growth mainly through saving money to build more equipment, more workers, better ways to work, and new technology. The difference between these two ideas is that the neoclassical theory focuses on the ability to make things and how the market fixes itself to reach balance. Keynes said that even if a country can make more it might not if people and businesses do not spend enough. In this conflict-between the two ideas, the Keynesian theory looks at the problem of not spending. It explains how total spending and real demand turn the ability to make things into production and the money people earn [30].

2.2 Economic Growth

The economy gets bigger when it makes things and provides more services over time. We can look at the income of a country, which is also called gross domestic product or GDP to see if the economy is really growing. Economic growth is what happens when a country's economy is doing well and producing goods and services. Economic growth is also influenced by military spending and trade variables, which are factored into GDP calculations [31].

2.3 Non-Fossil Energy Consumption

Non-fossil energy consumption is about using energy that does not come from fuels like coal or oil. We get fossil energy from things like hydropower, wind, solar, biomass, geothermal, and nuclear energy. Non-fossil energy is different, from other kinds of energy because it does not use coal, oil, or natural gas. Non-fossil energy is part of the energy mix. We use fossil energy, and it is an important part of the energy we use. Non-fossil energy consumption is something we need to think about when we talk about fossil energy. Non-fossil energy helps to reduce pollution. Non-fossil energy is good, for the environment. Non-fossil energy is important, for the planet. Non-fossil energy is a way to power the world. Non-fossil energy is the way. Non-fossil energy is a choice. Non-fossil energy consumption shows a change in how energy is used toward cleaner options, lower emissions, and more sustainable choices. This type of energy use is important because it can reduce reliance on fuels cut down on greenhouse gas emissions improve energy security, and help support more sustainable economic growth [32].

2.4 Agricultural Exports

Agricultural exports are the selling of products from a country to foreign markets. These products include food crops, plantations, horticulture, livestock and other agricultural raw materials. Agricultural exports show how well the agricultural sector can

meet the needs of the world, grow the production market, and bring in more money from other countries. Agricultural exports are very important for development because they can help farmers earn more money make the agribusiness chain stronger make the products more competitive and help the economy grow through trade, with other countries [33].

2.5 Technological Innovation

Technology is really important for making things better. It is the process of making things like machines and computer systems to help people work smarter. This can include finding ways to make things using new tools and making old systems better. Technology helps the economy in a way. It can make companies stronger reduce costs, and help them compete with others. Technology can also help the economy grow by making the most of what we have and adding value to the things we make. Overall technology is very important for making progress and helping the economy. It includes things like machines, computers and ways of doing things. Technological innovation like technology is about making things better and smarter. It helps people and companies work better and make things. Technological innovation is really good, at helping the economy because it makes things more efficient and helps people make the most of what they have [34].

3 Method

This study uses a quantitative approach with an associative framework and dynamic panel data from 2004 to 2023. The research objects are the countries that're part of BRICS. These countries are Brazil, Russia, India, China, South Africa, Indonesia, Egypt, Iran, Ethiopia, and the United Arab Emirates. The choice of these countries was made because they have data. The choice of these countries was made because they have consistent data. This data is needed for the Generalized Method of Moments estimation. The Generalized Method of Moments estimation requires quality data. The countries selected have data that meets the requirements for the Generalized Method of Moments estimation. Non-fossil energy consumption was chosen because BRICS countries have large energy needs, an increasingly strong energy transition agenda, and a strategic role in changing the global energy structure. This variable is important to analyze because the use of non-fossil energy not only reflects a shift from fossil fuels to more sustainable energy sources but is also related to a country's ability to maintain energy security, reduce dependence on fossil fuels, and encourage economic growth through increased consumption of cleaner energy.

The time from 2004 to 2023 was picked because it includes the BRIC countries coming together after Jim O'Neill from Goldman Sachs used the term BRIC in 2001. This was a time for the BRIC countries because Brazil, Russia, India, and China started to become major players in the world economy. The BRIC countries were becoming strong. This was a big deal. The BRIC countries were changing how the world economy worked. 2005 was also a crucial year because the Kyoto Protocol officially came into force, so that the issues of emission reduction, energy transition, and the use of non-fossil energy began to receive stronger policy pressure. This period is relevant to observe how non-fossil energy consumption moves within the framework of the economic growth of BRICS member countries.

The time from 2003 to 2023 is very important. This is because it includes the 2008 crisis. This is because it includes the 2008 financial crisis. This crisis made people buy less, trade less, and invest less. It was hard for developing countries to have a stable economy. The 2008 global financial crisis is important for this study. This is because agricultural exports are connected to food security, the money a country earns from other countries, and how well a country can keep its economy going during tough times. Agricultural exports are not just about trading goods. They are also about making sure people have food to eat. Sustainable Development Goals, were set in the year 2015. These goals made agricultural exports more important. Now, economic development is not just about making things. It is also about making sure people have food to eat, producing food in a way that's good for the environment, and making sure international trade is fair. The time from 2003 to 2023 also includes the COVID-19 pandemic in 2020. How did the economy get better from 2020 to 2023? The pandemic made the economy grow more slowly; it was hard to get things from one place to another. People were worried about food, energy and technology. New technology is very important. This is because the economy is getting better and it needs investment, digital technology and countries need to be able to adapt. The year 2023 is a deadline for this study. This is because it shows what happened after the pandemic and how the BRICS countries are growing. The thing, about the BRICS countries is that they are really growing. In the year 2023 some

new countries were invited to join the BRICS group. The BRICS countries are getting bigger and stronger. These countries are Egypt, Ethiopia, Iran and the United Arab Emirates. The time from 2003 to 2023 is long enough to see how exports, and using energy that is not from fossil fuels affect the economy of the BRICS countries. Agricultural exports and technological innovation are important for BRICS growth. The definitions, indicators, measurement scales, and data sources of the research variables are presented in Table 1.

Table 1. Variable Definitions

Variables	Indicator	Scale	Data source
Economic Growth (EG)	Annual GDP growth rate (%)	Ratio / %	World Bank
Non-Fossil Energy Consumption (NFE)	Renewable energy consumption (% of total)	Ratio / %	World Bank; International Energy Agency (IEA)
Agricultural Exports (AE)	Percentage of Total Agricultural Export Statistics (%)	Ratio / %	World Bank; United Nations Conference on Trade and Development (UNCTAD)
Technology Innovation (IT)	Gross domestic spending on R&D (% GDP)	Ratio / %	Organization for Economic Co-operation and Development (OECD)

Source: created by the author

The dependent variable of this study is economic growth (EG), measured by annual GDP growth (%), while the independent variables consist of non-fossil energy consumption (NFE), indicated by renewable energy consumption to total energy consumption (%); agricultural exports (AE), measured by the percentage of total agricultural exports (%); and technological innovation (IT), represented by gross domestic spending on R&D to GDP (%). This study uses panel data of BRICS member countries for the period 2004 to 2023 sourced from international institutions, namely the World Bank, the International Energy Agency (IEA), the United Nations Conference on Trade and Development (UNCTAD), and the Organization for Economic Co-operation and Development (OECD).

This study uses 200 panel observations obtained from 10 BRICS member countries from 2004 to 2023. With four research variables: economic growth, non-fossil energy consumption, agricultural exports, and technological innovation, the total number of data processed is 800. This number is considered sufficient to support the dynamic panel model estimation in this study [35], [36].

The GMM estimator was chosen to deal with endogeneity that comes from the way economic growth changes over time and from factors outside the model that might affect the results. Endogeneity happens when one of the variables we are looking at is connected to the error term, which can lead to unstable results. Non-fossil energy consumption, agricultural exports and technological innovation might be influenced by things we don't see that also affect growth. This could mean these variables are linked to the error term. Also, when we use past growth like $Y_{i,\square_{-1}}$ it can cause more endogeneity. To fix these problems the first-difference GMM equation uses values from t−2 and earlier as instruments for $Y_{i,\square_{-1}}$: non-fossil energy consumption, agricultural exports, and technological innovation. The System GMM level equation uses the differences of these same variables as tools.

This study uses a kind of estimation model that looks at information from many countries over time. The model is called a panel data approach and it uses something called the Generalized Method of Moments. We used a computer program called Stata 17 to look at how some things affect the economy of countries. We wanted to see how using energy from fossil sources, selling farm products to other countries, and coming up with new technologies impact the economy of countries like Brazil, Russia, India, China, South Africa, Indonesia, Egypt, Iran, Ethiopia, and the United Arab Emirates. We looked at information from these 10 countries from 2004 to 2023. We chose to use this model because it helps us understand how the economy changes over time, and it also helps us deal with some problems that can happen when we look at information from countries at once. The model we used is set up in the following way:

$$Y_{it} = a + \gamma Y_{i,t-1} + \beta_1 NFE_{it} + \beta_2 AE_{it} + \beta_3 TI_{it} + \epsilon_{it} \quad (1)$$

Equation (1) shows a dynamic panel model to examine the effects of non-fossil energy consumption, agricultural exports, and technological innovation on the economic growth of BRICS member countries. In equation (1), denotes the

country index and denotes the year index. denotes the country's economic growth in year , as measured by annual GDP growth. captures non-fossil energy consumption, represents agricultural exports, and denotes technological innovation in country and year . The inclusions account for the dynamics of economic growth, while the coefficients measure the degree of growth persistence. The coefficients , , and are interpreted as short-run effects because they capture the contemporary impact of non-fossil energy consumption, agricultural exports, and technological innovation on economic growth, respectively, after controlling for prior period economic growth. The error term reflects country- and year-specific factors that are not captured in the model but could potentially influence economic growth.$itY_{it}itNFE_{it}AE_{it}TI_{it}itY_{i,t-1}\gamma\beta_1\beta_2\beta_3\varepsilon_{it}$

The estimation uses a dynamic panel GMM because its presence can lead to dynamic endogeneity, so conventional estimators have the potential for bias. In the Arellano–Bond Difference GMM, the equation is transformed through first differentiation to reduce bias due to panel dynamics, while potentially endogenous variables are instrumented using appropriate lagged values. In the Blundell–Bond System GMM, the model is estimated simultaneously in first-difference and level forms, so that additional instruments can strengthen the estimation, especially when the variables of economic growth, non-fossil energy consumption, agricultural exports, and technological innovation show interperiod persistence.$Y_{i,t-1}$

To assess the long-term impact of non-fossil energy consumption, agricultural exports, and technological innovation on the economic growth of BRICS member countries, namely Brazil, Russia, India, China, South Africa, Indonesia, Egypt, Iran, Ethiopia, and the United Arab Emirates (UAE) during the period 2004 to 2023, a long-run relationship is obtained from a dynamic panel GMM model through long-run multipliers. This relationship shows the economic growth response after the entire dynamic adjustment process has fully taken place. Under the stability condition, the long-run specification is stated as follows:

$$Y_{it} = \theta_1 NFE_{it} + \theta_2 AE_{it} + \theta_3 TI_{it} \qquad (2)$$

In equation (2), denotes the country index and denotes the year index. denotes the country's economic growth in the year. represents non-fossil energy consumption, denotes agricultural exports, and denotes technological innovation. The parameters are long-run coefficients that describe the cumulative effect of non-fossil energy consumption, agricultural exports, and technological innovation on economic growth after the dynamic effects of economic growth in the previous period are accommodated. Consistent with the dynamic short-run model:

$$itY_{it}itNFE_{it}AE_{it}TI_{it}\theta_1\theta_2\theta_3$$
$$Y_{it} = \alpha + \gamma Y_{i,t-1} + \beta_1 NFE_{it} + \beta_2 AE_{it} + \beta_3 TI_{it} + \varepsilon_{it}$$

The long-term impact is calculated through the long-term multiplier as follows:

$$\theta_1 = \frac{\beta_1}{1-\gamma}, \theta_2 = \frac{\beta_2}{1-\gamma}, \theta_3 = \frac{\beta_3}{1-\gamma}$$

The formulation links short-term influences with the persistence of economic growth. The coefficients, and indicate how much non-fossil energy consumption, agricultural exports, and technological innovation affect economic growth in the long run. Equation (2) focuses on the long-term structural contribution of each independent variable, while the coefficient values are obtained from the estimated short-term GMM parameters.$(\beta)(\gamma)\theta_1\theta_2\theta_3$.

The long-run effects of fossil energy consumption, agricultural exports, and technological innovation are what we are looking at. These effects are like the response we get from the direct coefficients and the way the economy adjusts over time. We use these coefficients, which are β_1, β_2 and β_3 and the dynamic adjustment, which is γ to figure out the long-run effects. We calculate the long-run multipliers, which're θ_1, θ_2 and θ_3 using the formula: $\theta_1 = \frac{\beta_1}{1-\gamma}$, $\theta_2 = \frac{\beta_2}{1-\gamma}$ and $\theta_3 = \frac{\beta_3}{1-\gamma}$. When we look at the run, where the economy is stable, the lagged dependent variable is not a separate term because its effect is already included in the long-run multiplier. So θ_1, θ_2 and θ_3 show us the long-run effects of non-fossil energy consumption, agricultural exports, and technological innovation. We get these effects, from the short-run coefficients and the persistence parameter γ not from looking beyond the study period.

Before developing estimates from the data, several analytical processes must be performed. Verifying the GMM model specification involves several critical evaluations. The Instrument Validity test is meant to check that the instrument does not have any connection with the error term that is left over after the model is built. The Instrument Validity test applies the Sargan Test, which says that an instrument is, considered valid when the p-value is higher than 0.05. The Arellano-Bond

Consistency Test evaluates residual autocorrelation. This test states that a p-value exceeding 0.05 indicates the absence of second-order serial autocorrelation. This indicates that the model is coherent. The Uniqueness Test verifies that the resulting estimates are precise and align with the actual parameter values. The uniqueness of the GMM model is ensured by comparing its estimated values with those obtained from the CEM and FEM techniques. If the GMM estimation results fall between the FEM and PLS estimates, the GMM model is considered valid.

The Short-Term Significance Test, which is also called the Z-Test is really important for figuring out how independent variables affect things in the term. When we make decisions, we think that if the p-value of the Z-Test is less than 0.05, then the independent variable has a big impact on the dependent variable for a short time. The Long-Term Significance Test, which is also called the Wald Test, looks at how independent variables and dependent variables are related over time. We use this test to make decisions. If the p-value of the Wald Test is, less than 0.05, then we think the independent variable has a big impact on the dependent variable in the long term. This helps us understand the Short-Term Significance Test and the Long-Term Significance Test and how they use the Z-Test and the Wald Test to measure the effects of the variables.

4 Results and Discussion

4.1 Results

The results of the validity test of the Generalized Method of Moments (GMM) instrument show that the instruments used in the model meet the estimation feasibility for assessing the influence of non-fossil energy consumption, agricultural exports, and technological innovation on the economic growth of BRICS member countries.

Table 2. Instrument Validity Test

Sargan test of over-identification restrictions H0: The over-identification restriction is valid	
chi2(152)	= 176.4285
Prob > chi2	= 0.0853

Source: Author's analysis using Stata Version 17 data

Instrument validity was checked using the Sargan test for overidentification restrictions. This test looks at whether the instrumentsre all exogenous. That means the instruments do not have any relationship with the error term in the equation. It also checks if the moment conditions are correct. As shown in Table 2 the Sargan statistic has a value that comes with a probability of 0.0853. Because this probability is higher than 0.05 the test does not show that the instruments are not exogenous at the 5% level of significance. This means there is no proof that the instruments create any bias. The instruments chosen are good enough for GMM estimation. These instruments are used to look at the impact of fossil energy use, agricultural exports and technological progress on economic growth, in BRICS countries $\chi^2(152) = 176.4285$.

Table 3. Arrelano Bond Consistency Test

Arellano–Bond test for zero autocorrelation on first-differenced errors H0: No autocorrelation		
Order	z	Prob > z
1	-2,693	0.0071
2	.7753	0.4382

Source: Author's analysis using Stata Version 17 data

The results of the Arellano–Bond test presented in Table 3 yield a statistic. The observed statistic has a probability value of 0.4382. The Arellano–Bond test yields a probability value of 0.4382, exceeding the 0.05 threshold set for the test. The Arellano–Bond test shows no evidence of autocorrelation in its procedure. The results of the Arellano–Bond test are significant because they demonstrate the consistency of the GMM specification. This consistency is advantageous because it indicates that the model has been accurately stated regarding serial correlation diagnostics. Accurately defined GMM specifications improve the mechanisms and long-term impact of the parameters calculated within the GMM framework.

Table 4. Bias Diagnostics (Boundary Conditions)

Variable	fdgmm	sysgmm	woman	pls
EG L1.	.2452133	.2925789 6	.1967373 6***	.5692254 4***
nfe	1.590730 9	2.02403 72*	1.129598 6	1.306200 1**
ae	1.284468 7***	1.26730 09*	.8894061 4	.8673216 5*
ti	2.332973 2*	2.72624 9*	1.156439	- .8354664 2
_cons	- .7599885 2	- 1.31856 92	.8848648 4	1.427104 8
N	180	190	190	190

Source: Author's analysis using Stata Version 17 data

Bias diagnostics in dynamic panel models are used to assess whether the coefficient of the lagged dependent variable, namely the coefficient on , is within the theoretical range of the reference estimator. The Pooled OLS (PLS) estimator is generally an upper bound because it ignores country heterogeneity that does not change over time, while the Fixed Effect Model (FEM) is generally a lower bound due to the presence of finite sample bias in dynamic panel models. In a credible instrument strategy, the System GMM estimate is expected to be between the two estimators. Based on Table 4, the sysGMM coefficient value of 0.29257896 is between the FEM value of 0.19673736 and the PLS value of 0.56922544. This result meets the condition, so the System GMM estimate can be stated to be within a reasonable range and supports the validity of the dynamic panel model used $(\gamma)Y_{i,t-1}0{,}19673736 < 0{,}29257896 < 0{,}56922544$

This sequence indicates that sysGMM mitigates the downward bias associated with FEM and the upward bias associated with PLS. Therefore, the estimated dynamic effects fall within a theoretically plausible range and are not dominated by estimator bias. Overall, this pattern supports the interpretation that the GMM specification used in this study can be considered practically unbiased. Since this study uses secondary dynamic panel data, the N value refers to the number of country-year observations used by each estimator. The difference between the two reflects the estimator-specific effective observations after applying the requirements of each method, specifically the availability of lagged values, the formation of the lag structure, and the construction of moment conditions in the dynamic panel GMM estimation $N = 180\, N = 190$. The results of the short-term significance test using the GMM estimation are presented in Table 5.

Table 5 Short-Term Significance Test (Z-Test)

EG	Coefficient	Robust std. err.	z	P>|z|	[95% conf.
eg L1.	.1967374	.1244887	1.58	0.114	-.047256
nfe	2.024037	.8958407	2.26	0.024	.2682216
ae	1.267301	.5151331	2.46	0.014	.2576586
ti	2.726249	1.099504	2.48	0.013	.5712605
_cons	-1.318569	1.687001	-0.78	0.434	-4.625031

Source: Author's analysis using Stata Version 17 data

Based on the GMM estimation, here is the short-run equation:

$$Y_{it} = -1.318569 + 0{,}1967374\, EG_{it-1} + 2.024037\, NFE_{it} + 1.267301 AE_{it} + 2.726249\, TI_{it}$$

The results of our study show that the economy of BRICS countries does well when the economy did well in the past. It also does well when these countries use energy that's not from fossil fuels, export farm products, and come up with new technology. We found out that if the economy grew by 1 percent in the past it will grow by 0.20 percent now. This means that what happened to the economy in the past has an effect, on what happens. The economy of BRICS countries keeps growing from one period to the next. It is not the main reason why it grows. BRICS economic growth is connected to the past you can see this with EG_{it-1}

Non-fossil energy consumption has an impact. If non-fossil energy consumption goes up by one percent the economy gets a boost of 2.02 percent. This is a thing because non-fossil energy consumption helps the economy by giving us cleaner energy and making us less dependent on fossil fuels. Non-fossil energy consumption is really important for the economy. Agricultural exports are also very important. If agricultural exports increase by one percent the economy grows by 1.27 percent. This is because agricultural exports bring in money from other countries and they help our farmers sell their products. Agricultural exports also make our food supply more secure. Non-fossil energy consumption and agricultural exports are both good, for the economy. They help the economy in different ways. Non-fossil energy consumption gives us energy and agricultural exports bring in more money and food.

The thing that helps the economy grow the most is innovation. It has an effect, of 2.73. So if technological innovation goes up by 1 percent, the economy will grow by 2.73 percent as long as everything else stays the same. This big effect shows that technological innovation is the important thing in the model because it can make production better, increase the amount of work that gets done, and help create more economic value faster. The baseline value of growth is -1.32 when all the other things in the model are set to zero. Overall, technological innovation helps the economy grow the most, followed by using fossil energy and exporting agricultural products in the BRICS member countries. Technological innovation is

really important for growth in these countries and it has a big impact, on the economy

Table 6. Long-Term Significance Test (Wald Test)

EG	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
nfe	2.51977	1.27688	1.97	0.048	.0171319	5.022408
ae	1.577692	.6790568	2.32	0.020	.2467665	2.908619
ti	3.39397	1.191382	2.85	0.004	1.058905	5.729035

Source: Author's analysis using Stata Version 17 data

Based on the GMM estimation, here is the long-run equation:

$$Y_{it} = 2.51977\, NFE + 1.577692\, AE_{it} + 3.39397\, TI_{it}$$

The results of the Wald test in Table 6 are really important for the term. If we look at the estimates from the GMM, we can see that non-fossil energy consumption, agricultural exports, and technological innovation all have an effect on the economy of BRICS member countries. Non-fossil energy consumption is particularly interesting. It has a coefficient of 2.52 and a probability value of 0.048, which's less than 0.05. This means that if non-fossil energy consumption goes up by 1 percent the economy of BRICS member countries will grow by 2.52 percent in the term. The non-fossil energy consumption results show that non-fossil energy consumption plays a role in making the economy of BRICS member countries stronger by making energy more sustainable, reducing the need for fuels, and helping to keep the economy of BRICS member countries stable. Non-fossil energy consumption is very important for the economy of BRICS member countries in the long term.

Agricultural exports have a coefficient of 1.58 and a probability value of 0.020, which's less than 0.05. This means that if agricultural exports go up by 1 percent economic growth will go up by 1.58 percent in the term. This finding shows that agricultural exports help growth by increasing foreign exchange earnings, expanding markets for agricultural products, making the agribusiness value chain stronger, and helping with food security. Technological innovation has a coefficient of 3.39 and a probability value of 0.004. This means that if technological innovation rises by 1 percent economic growth will rise by 3.39 percent in the term. The size of this coefficient proves that technological innovation is an important factor because it can improve production efficiency, increase productivity, make the economy more competitive, and create long-term economic value.

4.2 Discussion

4.2.1 The Impact of Non-Fossil Energy Consumption on Economic Growth in BRICS Member Countries in the Short and Long Term

The results of short-term tests of fossil energy consumption show a number of 2.024037 with a probability value of 0.013, which is smaller than 0.05. This means that non-fossil energy consumption has an influence on the economic growth of BRICS countries. The long-term test shows a number of 3.39397 with a probability value of 0.004, also less than 0.05. This means that non-fossil energy consumption is still very important for the growth of BRICS countries in the long run. Non-fossil energy consumption is like a substitute for fuels that are more expensive. This helps to reduce energy costs and make expenditure more efficient. John Maynard Keynes said something about growth in 1936. He said that expenditure is the thing that drives economic growth. So when we use, non-energy consumption, we can save money on energy costs. Then we can use this money for things, that help the economic growth of BRICS countries to be more stable and sustainable. This is what happens when we shift our energy expenditure to sources like non-fossil energy consumption. We can then use our resources for things, that support more stable and sustainable economic growth in BRICS countries.

These empirical findings indicate that the use of non-fossil energy offers significant economic benefits because it is cheaper and more stable than fossil fuels. The use of non-fossil energy reduces dependence on expensive and volatile energy sources, allowing for energy cost savings. These savings allow financial resources previously allocated to energy to be diverted to consumption sectors boosting domestic economic activity. BRICS member countries, with their potential in non-fossil energy particularly renewable energy sources such as hydroelectric, solar, and wind, have the opportunity to reduce their need for fossil fuels, which in turn reduces foreign expenditure and strengthens their domestic economies. The transition to non-fossil energy not only reduces energy expenditure but also creates investment opportunities, increases people's purchasing power in other sectors, and drives short- and long-term economic growth.

4.2.2 The Impact of Agricultural Exports on Economic Growth in BRICS Member Countries in the Short and Long Term

The results of the short-term test show that agricultural exports are really important. Agricultural exports have an impact with a value of 1.27 and this is very likely to be true because the probability is 0.014, which is less than 0.05. The long-term test also shows that agricultural exports have an impact with a value of 1.58 and a probability of 0.020. This means that agricultural exports are good for the economy in the run. Agricultural exports help the economy of BRICS member countries to grow in the future. This is what John Maynard Keynes said in 1936. He believed that when a country sells things to other countries it is good for the economy. When agricultural exports go up more, people want to buy the things we make, so we get money from other countries. This makes our country richer. Agricultural exports also help farmers make things and this creates more jobs. So agricultural exports are not just good for trade; they also help make sure we have food, and they help the economy grow. Agricultural exports are really good, for the economy of BRICS member countries. They help with food and economic growth.

Agricultural exports are really important for the economy of BRICS member countries. They help these countries grow economically by making trade in things like food and other commodities stronger. When BRICS countries export food and other farm products, it helps their own markets at home earn more money from other countries and makes the whole business of farming stronger. Agricultural exports are very important for BRICS countries because they already produce a lot of food and need to make sure everyone has enough to eat. They also have a position in the global trade of commodities. Exporting farm products does not just help the people who work in farming it also makes the products more competitive. Ensures that there is a steady supply of food. So agricultural exports have a good effect, on the economy of BRICS countries because they can turn the food they produce into money from other countries and make their own economy stronger. The fact that agricultural exports help the economy of BRICS countries shows that these countries can use their ability to produce food to earn money from countries and make their economy stronger.

4.2.3 The Impact of Technological Innovation on Economic Growth in BRICS Member Countries in the Short and Long Term

The results of the short-term tests for innovation are pretty clear. They show a coefficient of 2.73 and a probability value of 0.013, which's lower than the 0.05 significance level. What this means is that technological innovation has a positive effect on the economic growth of BRICS member countries in the short term. It is positive and significant. The long-term tests show results. They, have a coefficient of 3.39 and a probability value of 0.004. So technological innovation still has a significant effect in the long term. To put it simply, if technological innovation goes up by 1 percent, economic growth goes up by 2.73 percent in the short term and 3.39 percent in the long term. This is what John Maynard Keynes said in his theory of growth back in 1936. He believed that technological innovation is a part of investment spending, which helps create aggregate demand. When technological innovation increases, it means there is investment spending on research and development, new production technology, digital systems, and making capital stronger. This kind of investment spending creates demand for things like capital goods, skilled labor and support services. As a result, production activity and national output go up. For the BRICS countries, technological innovation is really important for improving productivity, efficiency, and economic growth in both the short and long term. Technological innovation is a tool for achieving this. The effect of innovation, on economic growth is very clear. Technological innovation helps growth in the short term and the long term.

These empirical findings show that technological innovation brings economic benefits by making production more efficient, improving how much workers can produce, and increasing the value of what is produced. More technological innovation leads to the use of more effective production methods, digital systems, and stronger research and development in economic activities. This results in production processes with more predictable costs and higher production capacity. BRICS member countries have an industrial base, big domestic markets and strong needs for economic change, which makes technological innovation an important tool for speeding up economic growth. More money spent on research and development not only makes the industrial sector more competitive but also creates new places to invest, increases jobs in technology-related areas, and improves the economy's ability to make high-value products.

These results show that technological innovation helps drive growth in BRICS countries both, now and in the future.

5 Conclusion

This study shows that using fossil energy has a good effect on the economy of BRICS countries. It helps the economy of BRICS countries in the short term and in the long term. Non-fossil energy helps the economy by making these countries less dependent on fossil fuels and using energy in a better way, and making the economy more stable. Agricultural exports also have an effect on the economy of BRICS countries. This is true in the short term and the long term. Agricultural exports help by bringing in money from other, making markets for farm products bigger, making the farm business stronger, the farm business stronger and helping to make sure people have enough food. Technological innovation is also good for the economy of BRICS countries. It helps in the short term and in the long term. Technological innovation is an important factor because it can improve production, increase productivity, make businesses more competitive, and add more value to the economy. These findings show that the economy of BRICS countries can be made stronger by using non-fossil energy, increasing agricultural exports, and investing in technology that is good for the environment. Non-fossil energy, agricultural exports, and technological innovation are all important for the economy of BRICS countries. They can help the economy of BRICS countries in many ways.

This research offers guidance for BRICS member countries through three areas. For energy that's not from, policies should be aimed at speeding up the move to clean energy by offering financial incentives, improving the infrastructure for renewable energy, and cutting reliance on fossil fuels, which are affected by changes in global prices. For exports from farming policies should concentrate on making farming more productive setting quality standards for products improving the quality of goods opening up more international markets and building a stronger chain of businesses in agriculture so that the farming sector helps with food security at home and also brings in money from exports and becomes better at competing around the world. For ideas and technology policies should focus on spending more on research and development, using better production methods, making the economy more digital, and working together between government, businesses, and research groups to make operations more efficient, more productive, and more valuable economically. Combining these three policy areas is important for creating better and longer-lasting economic growth for BRICS countries

This study looks at the BRICS countries. What took place between the years 2004 and 2023. It does not show what is happening with the economy, energy, food and technology after that time. The BRICS countries are a place to start, but we should look at other countries too. We should look at countries that aren't part of the BRICS group, like other members of the G20, the Next Eleven, or other countries that are growing fast. Future studies on the BRICS countries and other countries should include things like money spent on renewable energy, new green technology, how well the government works, whether people have enough food, whether countries trade openly with each other, and how much carbon is released into the air. This will help us understand how to make the economy grow in a way and how the BRICS countries and other countries can keep growing without hurting the environment.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the author(s) utilized artificial intelligence (AI) technologies solely for the purpose of linguistic refinement and grammatical correction. Following the application of these tools, the author(s) comprehensively reviewed, verified, and edited the resulting text. The author(s) maintain full accountability and responsibility for the accuracy, integrity, and final content of the publication.

Reference:

[1] A. Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations*. Strahan & Cadell : London, 1776. ISBN: 978-0226763750.

[2] D. Ricardo, *On the Principles of Political Economy and Taxation*. John Murray, 1817. ISBN: 978-0760765364.

[3] J. M. Keynes, *The General Theory of Employment, Interest and Money*. Macmillan Cambridge University Press, 1936. ISBN: 978-0230004764.

[4] S. Ghosh and K. Kanjilal, "Non-fossil fuel energy usage and economic growth in India : A study on non-linear cointegration , asymmetry and causality," *J. Clean. Prod.*, vol. 273, no. 2020, p. 123032, 2022, doi: 10.1016/j.jclepro.2020.123032.

[5] B. Behera, S. Sucharita, B. Patra, and N.

Sethi, "A blend of renewable and non-renewable energy consumption on economic growth of India : The role of disaggregate energy sources," *Environ. Sci. Pollut. Res.*, 2023, doi: 10.1007/s11356-023-31372-0.

[6] G. S. Mutumba, T. Odongo, F. Nathan, V. Bagire, and L. Senyonga, "Renewable and non-renewable energy consumption and economic growth in Uganda," *SN Bus. Econ.*, 2022, doi: 10.1007/s43546-022-00220-7.

[7] N. Christian, S. Sunday, and U. Osokogwu, "Modelling the impact of total energy consumption on economic growth and carbon emissions in sub-Saharan Africa," *Energy Strateg. Rev.*, vol. 61, no. April, p. 101840, 2025, doi: 10.1016/j.esr.2025.101840.

[8] E. Mamba and E. Ali, "Do agricultural exports enhance agricultural (economic) growth ? Lessons from ECOWAS countries," *Struct. Chang. Econ. Dyn.*, vol. 63, no. September, pp. 257–267, 2022, doi: 10.1016/j.strueco.2022.10.003.

[9] E. Yusuf, S. Musa, and H. O. Obi-anike, "Development and Sustainability in Economics and Finance Institutional reforms , agricultural export diversification , and resilience to external shocks : A pathway to sustainable growth in Nigeria," *Dev. Sustain. Econ. Financ.*, vol. 8, no. April, p. 100095, 2025, doi: 10.1016/j.dsef.2025.100095.

[10] D. T. Adu, V. Hartarska, W. Sawadgo, and H. Thompson, "Social Sciences & Humanities Open Reassessing the role of export diversification in driving economic growth in sub-saharan Africa," *Soc. Sci. Humanit. Open*, vol. 12, no. October, p. 102091, 2025, doi: 10.1016/j.ssaho.2025.102091.

[11] S. Yana and C. Rusmina, "World Development Sustainability A review of local commodity development and export strategies for coffee , cocoa , and major agricultural products," *World Dev. Sustain.*, vol. 8, no. May 2025, p. 100295, 2026, doi: 10.1016/j.wds.2026.100295.

[12] E. Aminullah, "Technological Forecasting & Social Change," *Technol. Forecast. Soc. Chang.*, vol. 202, no. February 2022, p. 123333, 2024, doi: 10.1016/j.techfore.2024.123333.

[13] R. Si, Y. Wang, M. Cao, and H. Wen, "Does green technology innovation promote green economic growth ? – Examining regional heterogeneity between resource-based and non-resource-based cities," *Int. Rev. Econ. Financ.*, vol. 94, no. June, p. 103406, 2024, doi: 10.1016/j.iref.2024.103406.

[14] T. Meirun, L. W. W. Mihardjo, M. Haseeb, S. Abdul, and R. Khan, "The dynamics effect of green technology innovation on economic growth and CO 2 emission in Singapore : new evidence from bootstrap ARDL approach," *Environ. Sci. Pollut. Res.*, vol. 28, pp. 4184–4194, 2020, doi: https://doi.org/10.1007/s11356-020-10760-w.

[15] M. M. A. Mohamed, P. Liu, and G. Nie, "Causality between Technological Innovation and Economic Growth: Evidence from the Economies of Developing Countries," *Sustain.*, vol. 14, no. 6, pp. 1–39, 2022, doi: 10.3390/su14063586.

[16] A. A. Rafindadi and I. Ozturk, "Impacts of renewable energy consumption on the German economic growth: Evidence from combined cointegration test," *Renew. Sustain. Energy Rev.*, vol. 75, no. July 2016, pp. 1130–1141, 2017, doi: 10.1016/j.rser.2016.11.093.

[17] Rusiadi, M. Hidayat, D. M. Rangkuty, K. F. Ferine, and J. Saputra, "The Influence of Natural Resources, Energy Consumption, and Renewable Energy on Economic Growth in ASEAN Region Countries," *Int. J. Energy Econ. Policy*, vol. 14, no. 3, pp. 332–338, 2024, doi: 10.32479/ijeep.15917.

[18] E. Berr, "Keynes and Sustainable Development," *Int. J. Polit. Econ.*, vol. 38, no. 3, pp. 22–38, 2009, doi: 10.2753/IJP0891-1916380302.

[19] M. A. D. Ilyas Okumus, Arif Eser Guzel, "Renewable, non-renewable energy consumption and economic growth nexus in G7: fresh evidence from CS-ARDL," *Environ. Sci. Pollut. Res.*, vol. 28, pp. 56595–56605, 2021, doi: https://doi.org/10.1007/s11356-021-14618-7.

[20] C. Urom, I. Abid, K. Guesmi, and G. Ndubuisi, "Renewable energy consumption, globalization, and economic growth shocks: Evidence from G7 countries," *Int. Trade Econ. Dev.*, vol. 31, no. 2, pp. 204–232, 2022, doi: 10.1080/09638199.2021.1961845.

[21] E. Dogan, B. Altinoz, M. Madaleno, and D. Taskin, "The impact of renewable energy consumption to economic growth: A replication and extension of Inglesi-Lotz (2016)," *Energy Econ.*, vol. 90, p. 104866,

2020, doi: 10.1016/j.eneco.2020.104866.

[22] P. Xie, Z. Zhu, G. Hu, and J. Huang, "Renewable energy and economic growth hypothesis : Evidence from N-11 countries Renewable energy and economic growth hypothesis :," *Econ. Res. Istraživanja*, vol. 36, no. 1, p., 2023, doi: 10.1080/1331677X.2022.2121741.

[23] N. P. Canh and S. D. Thanh, "The Dynamics of Export Diversification, Economic Complexity and Economic Growth Cycles: Global Evidence," *Foreign Trade Rev.*, vol. 57, no. 3, pp. 234–260, 2022, doi: 10.1177/0015732520970441.

[24] F. V. Bekun, Z. Sahin, M. P. Fumey, P. O. Agboola, and M. Bas, "Role of energy consumption , gross capital formation , and urbanization in determining economic growth in Spain : Evidence from non-parametric methods ☆," *J. Clean. Prod.*, vol. 540, 2026, doi: 10.1016/j.jclepro.2026.147484.

[25] Z. Liu and A. Jackson, "Technology in Society The interplay of technological innovation , human capital and civil liberties in advancing economic complexity and sustainable growth," *Technol. Soc.*, vol. 84, no. October 2025, p. 103134, 2026, doi: 10.1016/j.techsoc.2025.103134.

[26] N. Chrid, S. Saafi, and M. Chakroun, "Export Upgrading and Economic Growth : a Panel Cointegration and Causality Analysis," *J. Knowl. Econ.*, vol. 12, pp. 811–84, 2020, doi: https://doi.org/10.1007/s13132-020-00640-6.

[27] N. Gizaw, J. Abafita, and T. M. Merra, "Impact of coffee exports on economic growth in Ethiopia ; An empirical investigation Impact of coffee exports on economic growth in Ethiopia ; An empirical investigation," *Cogent Econ. Financ.*, vol. 10, no. 1, 2022, doi: 10.1080/23322039.2022.2041260.

[28] Y. Li and S. Solaymani, "Energy consumption , technology innovation and economic growth nexuses in Malaysian," *Energy*, vol. 232, p. 121040, 2021, doi: 10.1016/j.energy.2021.121040.

[29] H. Zhang, Y. Shao, X. Han, and H. Chang, "A road towards ecological development in China : The nexus between green investment , natural resources , green technology innovation , and economic growth," *Resour. Policy*, vol. 77, no. December 2021, p. 102746, 2022, doi: 10.1016/j.resourpol.2022.102746.

[30] V. Huwe and M. Rehm, "The ecological crisis and post-Keynesian economics – bridging the gap ?," *Eur. J. Econ. Econ. Policies*, vol. 19, no. 3, pp. 397–414, 2022, doi: https://doi.org/10.4337/ejeep.2022.03.08.

[31] B. A. Sakib, "Causal Relationship between Consumption Expenditure and Economic Growth in Bangladesh," *World J. Soc. Sci.*, vol. 1, no. 2, pp. 158–169, 2011.

[32] M. Bhattacharya, S. R. Paramati, I. Ozturk, and S. Bhattacharya, "The effect of renewable energy consumption on economic growth: Evidence from top 38 countries," *Appl. Energy*, vol. 162, pp. 733–741, 2016, doi: 10.1016/j.apenergy.2015.10.104.

[33] L. I. N. Ben-xi and Y. Y. Zhang, "Impact of the COVID-19 pandemic on agricultural exports," *J. Integr. Agric.*, vol. 19, no. 12, pp. 2937–2945, 2020, doi: 10.1016/S2095-3119(20)63430-X.

[34] T. T. Nguyen, T. Anh, T. Pham, H. Thi, and X. Tram, "Role of information and communication technologies and innovation in driving carbon emissions and economic growth in selected G-20 countries ☆," *J. Environ. Manage.*, vol. 261, no. January, p. 110162, 2020, doi: 10.1016/j.jenvman.2020.110162.

[35] J. T. Roscoe, *Fundamental Research Statistics for the Behavioral Sciences*. Holt, Rinehart and Winston, New York, 1975. ISBN: 0030919347.

[36] U. S. Roger Bougie, *Research Methods For Business: A Skill Building Approach, 8th Edition*. Wiley, 2016. ISBN: 9781119561224.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors contributed equally to this research, at all stages from problem formulation to final findings and solutions.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received to conduct this research.

Conflict of Interest

The authors have no conflicts of interest to disclose.

Creative Commons Attribution License 4.0 (Attribution 4.0 International, CC BY 4.0)

This article is published under the terms of the Creative Commons Attribution 4.0 License.
https://creativecommons.org/licenses/by/4.0/deed.en_US8