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Renewable Energy Consumption and Its Role in Driving Green Economic Growth in BRICS Nations

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ABSTRACT

In recent years, a significant boost in environmental degradation has been seen globally. This change in the environment not only disturbs the lifestyle of the people but also impacts the economic conditions of the nations. For this aim, green economic growth (GEG) is introduced that balances economic growth and environmental dynamics. GEG not only escalates economic growth but also preserves the usage of natural resources that help to mitigate environmental degradation and provide a better living standard to future generations. For this purpose, this research explored the impact of renewable energy sources (REC), GDP per capita (GDPC) and trade openness (TOS) on the GEG in the BRICS countries by taking the annual data from 1995 to 2021. The outcomes are concluded by using the PMG-ARDL. The PMG-ARDL is appropriate due to its uniqueness by combining the long run-homogeneity and the short-run heterogeneity in the panel data sets and making it ideal to analyze the relationship in the heterogeneous panels. The outcomes from PMG-ARDL stated a positive and significant relationship between REC, GDPC and TOS on GEG in the long run. While seeing the short-run findings, TOS and GDPC have a significant while REC has an insignificant relationship with GEG in BRICS nations. Considering these outcomes, BRICS nations should make strict policies and regulations to enhance sustainable, green and eco-friendly production practices that enhance the usage of RECC, TOS and GDPC; this contributes toward sustainable development i.e. GEG.

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1. Introduction

The escalating thread of climate change, driven by rising global carbon emission and environmental degradation has intensified the urgency to adopt the sustainable energy sources. Santikarn et al. (2021) stated that fossil fuels are a main source of the world emission and accounted for 75% emission, increase global warming, extreme weather events and ecological instability. Energy production and consumption contribute significantly in driving the long-term economic growth (Sebri, 2015). They also pose significant environmental challenges particularly with the use of the non-renewable energy sources i.e. petroleum, gas and coal etc. These fossil fuels contribute to enhance the CO2 emission and lead an increase in the energy costs over time. Bilen et al. (2008) and Terrapon-Pfaff et al. (2014) stated that an upsurge in the energy prices face the shortages that not only reduce the economic development but also contribute to poverty and climate change due to the higher environmental degradation. The need for alternative and renewable energy source is obvious. The US energy information system forested a 48% increase in the demand of energy globally till 2040 that putting more pressure on the environment. Gottschamer and Zhang (2016) stated that fossil fuels are a major source to produce the energy globally and significantly enhance the environmental pollution. Moreover, Conti et al. (2016) stated that there are very few suppliers of the fossil fuel that makes it necessary to explore sustainable energy options that are eco-friendly. Like

that, Vaona (2016) concluded the advantage of the renewable energy is its cost-effectiveness as it is cheaper than the energy produced by consumption the fuel. Green energy/renewable energy can enhance lifestyle of the nation and helps the governance to overcome the degradation (Alper & Oguz, 2016; Oláh et al., 2020). Mornoy et al. (2018) stated that global world is trying to mitigate their reliance on the fossil fuels from the last few years. From 2002, the European union countries had decided to generate their 20% energy from the RE sources. Svenfelt, Engström and Svane (2011) and Cheng et al. (2021) stated that RE currently fulfills about 19% of the global energy needs and this figure is to reach 50% by 2050.

These days, clean energy is important to enhance the sustainable development and also overcome the dependency on the fossil fuels. Wang and Shao (2019) reported that REC helps to escalate the environmental sustainability and lead the green growth. However, developing countries face different challenges while shift toward the RE due to the weak infrastructure, lack of technological innovation, investment and the economic policies. These issues make installing RE systems more expensive than the expectation. Zallé (2019) stated that clean energy has a very little influence on the EG due to these challenges. Government must implement strict policies to reduce the harmful environmental activities. Ahmed, Cary and Le (2021) stated that emission control standards, environmental taxes and tradeable pollution permits plays a significant role to protect the environment and promoting the GEG. Government policies boost the efficiency of energy production and consumption by encouraging the use of green technologies and taking energy efficiency measures. Yao et al. (2020) stated that government regulations significantly enhance the GEG. Moreover, they suggested that the governments should introduced the ecological policies by taxing companies that pollute the environment and offering tax benefits or incentives to that businesses that use the eco-friendly technologies. Opposite to this, Sun et al. (2022) stated that the weak environmental policies enhance the pollution by allowing industries to use the outdated and harmful technologies. The success of the environmental policies in promoting the sustainable growth depends on a country economic situation. Zhao et al. (2022) proposed that change of technology and increase in the resource efficiency enhance the greater economic productivity and long-term growth.

The theoretical framework is explained with the help of endogenous growth theory. In that context, RE, TOS and GDPC stimulates the sustainable growth through the innovations. Investment in the RE projects not only helps to reduce the CO_2 emission but also helpful to expand the industrial sector. This also create a positive initiative towards the GEG. Like that, TOS also support the green technologies and helps to escalate the trade that ultimately boost the GEG. Moreover, greater GDPC create the more spendings on the eco-friendly initiatives that drive towards the sustainable growth i.e. GEG. For the BRICs countries, REC has a vital role to achieve green GEG. GEG not only boost the economic development but also helps to mitigate the environmental pollution in the BRICS nations. By doing investment in the REC sources, the dependency on the costly energy equipment's decreases that helps to reduce the environmental degradation and also enhance the energy efficiency. Further, RE projects provides a number of job opportunities and also bring the FDI and the technological innovations. Through the use of RE, BRICS countries not control on their environmental issues but also enhance their economic development i.e. GEG. The aim of this study is to analyze the impact of REC, TOS and GDPC on the GEG in the BRICS countries from 1995-2021. BRICS countries were chosen for this research due to the fastest growing economies that significantly enhance the global trade, energy consumption and environmental sustainability. These countries are experiencing the successive increase in the population and industrial growth that led an increase in the energy demand. Parallel to this, BRICS nations are struggling to bring balance between environmental sustainability and EG. This argue make it ideal for this research. The diverse economic structure of the BRICS countries, trade policies and RE initiatives and provide valuable insights into how emerging economies can achieve sustainable development. Further, the GEG strategies of BRICS countries can have a significant influence on global environmental policies and climate change mitigation effects.

2. Literature Review

The impact of the REC on GEG has been studies in this section. By using the data of G20 countries, Ashfaq et al. (2024) investigated the influence of impact of REC on GEG with the help of dynamic ARDL model. They used the TOS and economic globalization as a moderator in their research. The outcomes reported a positive association in the variables during long-run.

Moreover, the study is novel by introducing the dynamic solutions to conclude the long run and short run relationships to obtain key insights of RE towards the sustainable environment. Like that, Using the panel data of BRICS countries, Zeng et al. (2024) explored the influence of REC on GEG and found that REC significantly boost the GEG in the China and India. As India and China are the two larger economies in the BRICS countries, so the investment in the clean technologies boost the EG and mitigate the carbon emission i.e. enhance GEG. Further, Xie et al. (2020)) investigated the influence of REC on GEG in the presence of the technological innovations. The findings from threshold model reported a N-shaped relationship between the variables. This is the first study in novelty that highlight the nonlinearity between REC and GEG and suggest the production of innovational technologies i.e. green development technologies. Also, Jia, Fan and Xia (2023) also examined the influence of REC on GEG in the Belt and Road initiative countries and reported a bidirectional relationship between them. There are two main components of the GEG i.e. EG and environmental policies. Sebri (2015) explored the influence of REC on EG in 46 countries and found a significant relationship between them. Using the data of 46 peer-review studies from 2010-2021, Bhuiyan et al. (2022) explored the impact of REC on EG in the high income and emerging economies and found mixed results from these ones. Some of the researchers declare that the REC escalate the EG. On the other hand, the findings from threshold effect stated that REC impact on the EG in the higher income level countries. Like that, Chen, Pinar and Stengos (2020) explored a nonlinear influence of REC on EG in OECD nations. The outcomes reported a positive association between them due to decrease in the cost and innovation. Further, Jia, Fan and Xia (2023) also concluded a significant influence of REC on EG in the 90 Belt and Road initiative countries.

Pejovic, Backovic and Karadzic (2025) also investigated a relationship between REC and EG in the European transition countries. The outcomes revealed a significant influence of REC on EG in long run. Like that, Raihan et al. (2025) also carried research on Egypt by examining the impact REC on EG from 1990-2021. The findings from ARDL reported a significant relationship between REC and EG. Further, Azam et al. (2025) investigated the association of REC on human capital in the 88 Asian countries using data from 1995-2018. The results reported a significant increase in human capital due to an upsurge in EG in these countries. Almulhim et al. (2025) investigated the influence of REC on the environmental policies in BRICS countries using data from 1996-2020. The outcomes from method of moment quantile regression showing the strong relationship with the environmental laws. Magazzino et al. (2022) investigated the impact of REC on environmental policies by using the data of Scandinavian countries from 1990-2018 and concluded a bidirectional relationship between them. Yahoo et al. (2024) analyzed the impact of REC on the subsidy reform to mitigate the carbon emission by using the CGE framework in the Malaysia. The outcomes revealed a significant impact of REC on the subsidy reforms. Hacıimamoğlu and Sungur (2024) investigated a relationship between REC and environmental degradation with the help of ecological footprint model. The findings reported that REC significantly reduce the ecological pressure but political stability is much important for this also. Moreover, they stated that EG enhance the environmental strain(Ragmoun, 2022, 2023a, 2023b, 2024).

Han et al. (2025) investigated a relationship between REC and environmental pollution by taking PMG-ARDL methodology in G20 nations. The results stated a significant decline in the pollution by using the REC sources. Further, Li et al. (2022) examined the impact of green energy investments with the REC to discourage the carbon emission from 1995-2020 by using data of bootstrap ARDL. The outcomes reported a significant decline in the carbon emission by interacting with REC. Moreover, they also reported a speedy decline in the emission in the presence of green technology investments. Dogan and Seker (2016) investigated a relationship between REC and carbon emission in 22 EU countries from 1990-2012 by using the dynamic ARDL. The results reported that REC significantly reduce the emission. Moreover, they stated that the relationship is pronounced in the high-income countries. Further, Sadorsky (2009) investigated a relationship between REC and CO emission from 1994 to 2003 by using the panel cointegration techniques. The findings reported a negative relationship between them i.e. REC reduce the emission. In the short, REC reduces very little amount of emission while impact affectively in the long run. Like that, Apergis and Payne (2010) explored a relationship using the data of 80 nations with the help of panel error correction model and report a significant impact of REC on the emission in developed and developing countries from 1990 to 2007. They stated that relationship is higher in OECD countries due to the better energy efficiency and the

policies. Inglesi-Lotz (2018) also conducted research on the impact of REC on emission from 1991-2011 by using framework of FMOLS and DOLS in BRICS countries. The results shows that REC reduces emission but fossil fuels dependency in some countries i.e. China and India weakened the effect. Parallel to this, Bilgili, Koçak and Bulut (2016) employed a panel approach for 17 emerging countries from 1980 to 2012 and reported a negative relationship between REC and emission. The impact varies from region to region. Biomass and hydropower showed the strongest negative correlation with emission while solar/wind had a lagged impact.Abbasi et al. (2024) analyzed the impact of digitalization on carbon emissions by using data from 1997 to 2018 and reported a significant impact between them. The outcomes declare that digitalization significantly reduces carbon emissions. Similarly, Saboor (2024) also stated that digitalization, especially blockchain technology, significantly reduces carbon emissions.

Wang and Li (2019) conducted research to analyze the influence of TOS on green growth (GG) in the Chinese provinces using the Durbin model. They found a significant spatial spillover, explained that TOS is beneficial for the regional growth. Like that, Ashfaq et al. (2024) explored that how financial development moderates the TOS and EG nexus in the Nigeria. The outcomes reported a positive association between the TOS and EG nexus. Kim, Wu and Lin (2025) examine the influence of TOS on GG arguing that its impact dependency on the environmental stringency policies and reported that TOS significantly boost the GG in the strong environmental policies. The study is novel due to the non-linear approach, challenging the assumption that TOS is good for the sustainable development. Putra and Oktora (2024) explored the impact of TOS on GG in the ASEAN countries using the GMM framework. The findings concluded that TOS significantly upsurge the GG in the presence of green and clean technologies. The study is novel due to its modern trade dimensions, offering fresh insights that how digitalization escalates the GG. Similarly, Xu et al. (2023) explored a relationship that whether TOS enhance GG by taking REC as a mediating role in the South Asia. The findings from SEM reported TOS upsurge the GG and indirectly support the sustainability by investing the RE projects. Hence no study has been found in the literature that investigate the influence of REC, TOS and GDPC on GEG in the BRCIS countries. This study also describes a complete overview on the GEG. Further, this study is conducted with the latest data set. In this, we fill this gap by conducting this research.

3. Theoretical Framework

This study provides a theoretical framework in the presence of the endogenous growth theory which explains that how technological innovations help economies to enhance their growth in the long run. Chou, Ngo and Tran (2023) stated that RE plays a significant role in the GEG by reducing its dependency on the fossil fuels and promote the sustainable development. When the countries use the more renewable energy, they promote the latest environmentally friendly technologies that are more energy efficient and also mitigate the Co2 emission (Bhattacharya et al., 2016). Like that, trade openness also helps by allow the exchange of clean technologies that make countries easier to adopt the green technologies (Kim, Wu, & Lin, 2025; Wu, 2025). Similarly, GDP per capita shows the economic strength of a country that affects its ability to invest in the energy efficient and environmentally friendly technological projects (Alofaysan et al., 2024; Oláh et al., 2020). Considering the BRICS countries, they have high energy demand and have high percentage of environmental degradation that helps to understand the impact of REC on GEG. The overall framework allows to understand the impact of REC, GDPC and TOS on GEG in BRICS countries. In mathematical form, our model is stated as follow:

$$GEG = f(REC + TOS + GDPC) \quad (1)$$

In the econometric form, we write the model as follow:

$$GEG_{it} = \alpha_o + \alpha_1 REC + \alpha_2 TOS + \alpha_2 GDPC + e_{it} \quad (2)$$

In the above equation, GEG, REC, TOS and GDPC are our variables and stated as green economic growth, renewable energy consumption, trade openness and GDP per capita respectively. Like that, i and t shows the cross section and time respectively. Moreover, e_{it} is the error term during a specific time period and a cross section. The error term e_{it} captures the unobserved factors affecting on the GEG like omitted variables, measurement errors and the random shocks in the panel data set.

4. Data and Analysis

The aim of the study is to analyze the impact of REC, TOS and GDPC on the GEG in the BRICS countries. The reason to select these countries is their high economic growth while contributed significantly in the global emission. This research contains the dataset from 1995-2021 is obtained from world development indicator (WDI). GEG is measured by % of GNI while REC, TOS and GDPC are measured by the % of total final energy consumption, % of GDP and constant 2015 US$ respectively.

Table 1: Description of Variable

Variable	Symbol	Proxy	Data Source
Renewable Energy Consumption	REC	% of total final energy consumption	WDI
Green Economic Growth	GEG	% of GNI	WDI
GDP per Capita	GDPC	constant 2015 US$	WDI
Trade Openness	TOS	% of GDP	WDI

Summary statistics are displayed in the Table 2 and report that mean values of GEG, REC, TOS and GDPC are 8.71, 23.81, 42.44 and 5529.94 respectively. GEC has the lowest variation while GDPC shows the highest variation. All the variables are negatively skewed except REC. Further, GEG, REC, TOS and GDPC rejected the null hypothesis and stated that data derivates from the normal distribution.

Table 2: Descriptive Statistics

	GEG	REC	TOS	GDPC
Mean	8.71	23.81	42.44	55.29
Median	7.13	17.4	45.64	59.53
Maximum	27.0	50	69.39	11.22
Minimum	-26.39	3.20	15.63	620.70
Std. Dev.	10.40	16.99	12.85	29.86
Skewness	-0.33	0.19	-0.23	-0.19
Kurtosis	2.99	1.39	2.10	1.84
Jarque-Bera	0.02	0.00	0.05	0.01

*For p<0.1, ** for p<0.05, ***for p<0.01

5. Methodology

Pesaran, Shin and Smith (1999) proposed the PMG-ARDL that is used to analyze the long and short-run relationships in the panel data sets. The methodology is significant for the data from the different countries expect those ones where the economic relationships are same in the long run while shows different relationships in short run. The PMG ARDL helps us to analyze the long-run relationship while seeing the variations in short-run for different groups. CIPS unit root test is used to check the stationary level. It is used to examine the cross-sectional dependency in the panel data sets i.e. the variable are integrated at I(0) or I(1). In conclusion, we apply the PMG-ARDL investigate a relationship for short and long run. PMG-ARDL is used when economic variables are related in the long run but shows differently in policies, institutions and other economic conditions during short run. This helps PMG ARDL to capture the similarities and differences in the BRICS countries. For short run:

$$GEG_{it} = \alpha_o + \alpha_1 \Delta GEG_{it-1} + \alpha_2 \Delta REC_{it-1} + \alpha_3 \Delta TOS_{it-1} + \alpha_4 \Delta GDPC_{it-1} \quad (3)$$

For long run

$$GEG_{it} = \gamma_1 GEG_{it} + \gamma_2 REC_{it} + \gamma_3 TOS_{it} + \gamma_4 GDPC_{it} \quad (4)$$

By concluding the both equations

$$GEG_{it} = \alpha_o + \alpha_1 \Delta GEG_{it-1} + \alpha_2 \Delta REC_{it-1} + \alpha_3 \Delta TOS_{it-1} + \alpha_4 \Delta GDPC_{it-1} + \gamma_1 GHG_{it} + \gamma_2 REC_{it} + \gamma_3 TOS_{it} + \gamma_4 GDPC_{it} + e_{it} \quad (5)$$

While considering the equation (5), REC is the independent variable while GEG is dependent variable. Further, TOS and GDPC are our control variables while I and t shows the time and cross section respectively. Parallel to this, e_{it} is the error term.

6. Results and Discussion

We check cross-sectional dependency (CSCD) test before apply the PMG-ARDL. CSCD test is used to check the dependency of the variables. For our data, we employe the Pesaran (2004) CSCD test to examine. The below table shows the results of the CSCD test. The results of CSCD test stated the rejection of the null hypothesis that confirmed the presence of the CSCD in our study.

Table 3: CSCD Test

Variable	p-value
REC	0.00
TOS	0.00
GDPC	0.00
GEG	0.00

*For p<0.1, ** for p<0.05, ***for p<0.01

After examine the CSCD test, the CIPS unit root test proposed by Pesaran (2007) is used to check to check stationary level of the variables i.e. are they stationary or not. It will help to examine that CSCDs in panel data when a cross section is influence by other. Moreover, CIPS unit root test is significant in the panel data sets as it covers the integration and heterogeneity issues.

Table 4: CIPS Unit Root Test

Variable	I(0)	I(1)
GEG	-3.33	-
REC	-3.18	-
TOS	-1.46	-3.16
GDPC	-1.89	-2.45

*For p<0.1, ** for p<0.05, ***for p<0.01
1%, -2.58
5%, -2.33
10%, -2.21

Table 5: Short Run & Long Run Findings

Variable	Coefficient	Prob.*
Long Run Equation		
REC	1.17	0.00
GDPC	0.00	0.00
TOS	0.52	0.00
Short Run Equation		
COINTEQ01	-0.38	0.00
D(REC)	-0.42	0.11
D(GDPC)	0.00	0.03
D(TOS)	-0.21	0.00
C	-25.59	0.02

*For p<0.1, ** for p<0.05, ***for p<0.01

Considering long-run findings, it has been seen that REC has a significant and positive relationship on GEG. The results indicates that 1% increase in the REC results an increase of 1.17% in the GHG in long run. It stated that REC significantly boost GEG emission in the BRICS countries. This is due to the stable and clean sources of energy in the BRICS countries. BRICS nations are growing fast and need a lot of energy to support their industries. The usage of the renewable energy sources i.e. wind, hydro and solar mitigate the dependency on fossil fuel energy sources that pollute the environment. The renewable energy sources also create the new jobs that attract investment and encourage the innovation in the clean technology. With the passage of time, this leads to a stronger economy with the less pollution, better public health and lesser energy costs. In conclusion, BRICS countries can achieve long term economic growth while protecting the environment for future generation. The findings of our research are similar with the outcomes of Chhabra, Agarwal and Giri (2024); Xie et al. (2020) and (Taşkın, Vardar, & Okan, 2020).

Parallel to this, GDPC indicates a positive and significant relationship with the GEG in the long-run. No doubt, GDPC significantly enhance the GEG in the BRICS countries but the nature of their relationship is very negligible. This is due to an increase in the GDPC. As the GDPC increases, people have more interest in the cleaner and renewable energy technologies. The

stable or the well developing economies shifts themselves from fossil fuel energy sources to the renewable energy sources i.e. solar or the wind power plants that are beneficial for the environment. Further, higher GDPC also enhance the investment in the R&D fundings that results in the form of green innovations. Regarding the BRICS countries, India and China significantly invest to develop the eco-friendly technologies that not only enhance their economic growth but also helps to reduce the environmental degradation. Moreover, an increase in the GDPC results an increase in the living of the population that results in the demand of a cleaner environment. This pushes the government to adopt the green policies that significantly boost the economic growth of the country. Our findings are aligning with the research of Houssam et al. (2023); Lin and Zhou (2022) and Tawiah, Zakari and Adedoyin (2021).

Further, while considering the results for the long-run, TOS also has a positive and significant relationship with the GEG in the BRICS countries. The outcomes stated that a 1% upsurge in the TOS results an increase of 0.52% in GEG during long run. This reported that TOS significantly enhance the GEG in BRICS countries. The TOS helps the BRICS countries to exchange goods, services and technology with the other nations. The trade between two nations enhances the advanced green technologies i.e. energy efficient measures and renewable energy equipment that significantly enhance the production procedure and reduces the pollution. TOS also attracts the FDI from different nations that encourage the sustainable and green production procedures. Additionally, competition from global markets pushes local businesses to become more efficient and environment friendly. With the more technological innovations and resources, BRICS countries boost their growth by protecting the environment that leads towards the GEG Halim and Moudud-Ul-Huq (2024); Tariq et al. (2024) and Arif et al. (2022).

While analyzing the short run estimations, GDPC has a positive and significant relationship with GEG. The nature of the relationship is positive but it's very negligible. Higher GDPC allow the people and businesses to invest in the cleaner and sustainable practices. The higher income level of the people shits their lifestyle towards the energy eco-friendly products, electric vehicles or the energy efficient appliances that significantly reduces the pollution. Like that, industries having a good portfolio can spend more on the green technologies and energy efficient production practices. Due to a stable and growing economy, government collect more taxes and invest them in the green or the environment friendly projects. In conclusion, a higher GDPC enables GEG by enhancing the investment in the sustainable and eco-friendly projects. The results are familiar with the finding of Hussain et al. (2022) and Tawiah, Zakari and Adedoyin (2021). On the other hand, a negative but significant relationship has been seen between the TOS and GEG in the short run. The results reported that 0.21% increase in the GEG occurred due to an increase of 1% in the TOS during short run. This means that TOS discourage the GEG in the BRICS countries. When the trade is open, every country tries to enhance their exports to compete with other international firms. This results in the high energy cost due to the dependency of the fossil fuel energy sources that not only pollute the environment but also enhance the burning of natural resources. Further, some industries focus on the short-term growth rather their long-term achievements. This short-term growth provokes them to invest in the clean and the environment friendly technologies. So, the commodities imported from less environmental laws also enhance the environmental pollution. In conclusion, the dependency on the fossil fuel energy sources not only pollute the environment and create hurdles in the progress of the economic growth that ultimately results in the reduction of GEG. Wu (2025); Xu (2022) and Sheikh, Malik and Masood (2020) also concluded the negative but significant relationship of TOS on GEG in their studies. Parallel to this, REC has an insignificant impact on the GEG in the short run.

7. Conclusion

In this modern world, the level of environmental degradation has been gradually increasing. This increase in the pollution not only impact the living standard of the people but also disturb the economic situations of the nations. For this purpose, GEG is essential for the sustainable development as it balances between the economic progress and the environmental pollution. It not only enhances the EG of a nation but also significantly reduces the environmental degradation. GEG helps to reduce the emission that not only preserve the usage of the natural resources and also enhance the living standard of the future generation. This

research analyzes the impact of the renewable energy sources, trade openness and GDP per capita on the green economic growth in the BRICS countries by using the panel data from 1995 to 2021. The reason to choose BRICS nations i.e. Brazil, Russia, India, China and South Africa because they are among the world largest emerging economies that played a significant role in the global economic growth and environmental dilemma. These countries have experienced industrialization and economic growth that leads an increase in the energy consumption and environmental challenges. At the same time, BRICS nations are trying to shift towards the sustainable developments especially in the energy sector or the economic reforms. This not only helps them to control the environmental issues but also gives support to enhance the growth. Further, the BRICS countries have a diverse economic structure and policies that helps us to get a better understanding between the renewable energy consumption and economic growth.

This study provides the numerous findings by analyzing the relationship with the help of the PMG-ARDL. By considering the long-run outcomes, REC, TOS and GDPC has a positive and significant relationship with the GEG in the BRICS nations. This positive relationship is due to the promoting the sustainable and the technological advancements. This not only restrain the environmental issues but also helps to escalate the environmentally friendly economic growth. By seeing the short run outcomes, TOS has a negative while GDPC has a positive relationship with the GEG. Both TOS and GDPC have significant while REC has an insignificant relationship with the GEG during the short-run. The GDPC relationship is due to the investment in the green and sustainable technological innovations while TOS temporarily hinder the economic growth due to an increase in the industrial activities i.e. production. In conclusion, the outcomes suggests that BRICS countries should focus on the sustainable, green and the eco-friendly policies that upsurge the usage of the REC, enhance the GDPC and TOS to achieve long-term environmental and economic sustainability.

7.1. Policy Recommendations

This study also provides the several policy recommendations. BRICS countries should focus to enhance the usage of the REC by implementing the policies that enhance the use of clean energy sources i.e. wind, solar and hydropower. This will also help to escalate the GEG in the BRICS countries. The increase of the REC should be enhanced by providing the financial incentives and subsidies on the REC projects as well as investing int the R&D measures to enhance the energy efficiently. Moreover, the government should facilitate the transition by upgrading the energy infrastructure to support the renewable energy integration that decreases the fossil fuels dependency and mitigate the environmental degradation during long-run in the BRICS countries.

Further, BRICS countries should also prioritize policies that enhance the economic growth while ensuring that it is inclusive and sustainable. An increase in the income helps people and business mans to invest in the environmentally friendly technologies, products and services. The governments should focus on the economic reforms that promote the job creation, innovation and equitable growth. Moreover, awareness program regarding the green, sustainable and eco-friendly practices can enhance the adoption of the higher technologies that mitigate the environmental degradation and contributing to a long term GEG.

To enhance the significant impact of TOS on the GEG, BRICS countries should focus on the environmental standards into their trade agreements and ensuring the imposition of fixed eco-friendly criteria. Policies should be introduced to enhance the important and exportation of green technologies that promote the clear production practices in the industries. Moreover, government should implement regulations that mitigate the environmental impact of industrial activities associate with the trade that helps to move towards a sustainable or GEG.

This study also has some limitations. The study is conducted only for the BRICS countries, so the findings are not applicable for the other countries. Moreover, this research also ignores the various other control variables like human capital, foreign direct investment, technological innovation and the environmental laws. The further researchers can fill this gap by pursuing this study.

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