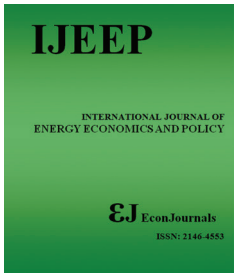

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The Impact of Fossil and Renewable Energy Consumption on the Economic Growth in Brazil, Russia, India, China and South Africa

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ABSTRACT

The energy consumption of the developing countries such as Brazil, Russia, India, China and South Africa (BRICS) continues to rise as the economic growth increases. The aim of this study was to analyze the effect of the consumption of the fossil fuels (coal, petroleum, and natural gas) and the renewable energy to the economic growth in the five BRICS countries. The analysis tool used was multiple linear regression using fixed effect model method and panel data on time series from 1995 to 2014. The results showed that the consumption of fossil energy, especially coal energy, positively and significantly affects the economic growth in the BRICS countries. However the renewable energy consumption a negatively affects the economic growth in the BRICS countries.

Keywords: Economic Growth, Consumption of Fossil Energy, Renewable Energy Consumption, Brazil, Russia, India, China and South Africa
JEL Classifications: Q42, Q43

1. INTRODUCTION

Economic growth brings a better civilization as it producespolicies that lead to the effort to support the development and the economic growth. For example, the innovation of science, technology, and trade are the product policies that aim to boost the economic growth of a country.

Meanwhile, the determinant factors of a country to be advanced are not only depend on itsnatural resourcesand geographical position, but also the existence of its energy sources as a formidable power to accelerate the economic activities of a country. Therefore, the more advanced or greater productivity of a country, the greater the use of the energy will be. In this context, the energy used can be categorized into non-renewable and renewable energy. The non-renewable energy is generally known as a source of energy derived from sediment microorganisms that have existed millions of years ago known as fossil energy resources with limited capacity such as coal, petroleum, natural gas, and others. Meanwhile, the renewable energy is an energy source from unlimited capacity of sources such as water, wind, sun, and others. In general, the consumption of the fossil energy is dominant in developing countries as it is efficient compare to the use of the renewable one which requires enormous costs to produce it. Kim and Heo (2012) found that there is a two-way causal relationship between economic growth and actual energy consumption; although, Mercan and Karakaya (2015) argued that energy consumption is negatively affected and has little impact on the economic growth in organization for economic co-operation and development (OECD) countries.

The use of these energies have been widely used in many countries including in the developing countries. In 2006, International Energy reported the world's energy consumption that always grew 2.3% every year. The study of Hedayat et al. (2017) on the utilization of renewable energy (wind energy) and natural ventilation in Iran indicated that as the performance of the natural ventilation is affected by the shaft/aperture exposed to wind direction, a wind tower that its axle/openings can be adjusted is for more effective for natural ventilation.

BRICS countries - Brazil, Russia, India, China, and South Africa - are among the developing countries predicted to have a big impact on the global economy due to their good performance on their economic growth and projected to be the most potentially influential countries in the world in the 21th century. In achieving their economic growth, the state must manage the environment to be well maintained. Castiglione et al. (2015) convey the importance of regulation and law in the utilization of energy for economic growth while maintaining the environment. Meanwhile, Shahbaz et al. (2014) put emphasis on the importance of policies to reduce pollutants and the implementation of environmentally friendly energy regulations to sustain economic development in Tunisia.

The economic growth of the BRICS countries is constantly increasing as they moved to be the industrialized ones. As a result, the need of energy is also increasing in order to accommodate the demand of many sectors such as industry, transportation, economy, and others. The increase of the energy consumption suggests the industrialization is in progress. Therefore, the higher the energy consumption of a country the faster the industrialization process will be. The relationship between energy use and gross domestic product (GDP) has been the subject of extensive academic research with varying findings. According to Ozturk (2010) and reinforced by Kalimeris et al. (2014), there is no general agreement on the nature of causal relationships (if any) between energy and GDP.

Given that situation, the objective of this study is to investigate the influence of the consumption of the fossil and the renewable energy onthe economic growth in BRICS countries (Brazil, Russia, India, China, and South Africa).

2. LITERATURE REVIEW

2.1. Energy in Production

Mainstream economists have postulated capital, labor, and land as the main factors of production, while materials such as fuel as the intermediate inputs. In growth theory, the approach focuses on the main inputs; capital and labor; while, the role of energy in the growth process has not been the focus of attentionasthe explicit role of energy does not exist. Energy is a factor of production that cannot be renewably; although, the energy (fuel) is a factor that can be reproduced. Therefore, natural scientists and ecological economists have put emphasis on the importance of the role of energy and its availability in the process of production and economic growth (Stern and Cleveland, 2004).

2.2. Growth Model without Resources

In the neo classical growth model of Solow (1956), growth is a transitional phase in which a state moves toward a stationary state. According to the neo classical growth theory, population growth, capital accumulation, and technological advancement causes continued economic growth. Solow growth model wasdeveloped based on a big idea that production and equation of capital accumulation function is described as follows

$$Y = F(K, L) = K^{\alpha}L^{1-\alpha}$$

Where production function is based on capital (K) and labor (L), and output is denoted by Y. This production function is assumed to have constant return scale properties. The model does not explain how technology improves as it is considered exogenous.

Growth and resources center on sustainable growth conditions, or at least non-declining consumption and utility. The technical conditions include a combination of renewable and nonrenewable resources, endowments, and natural resources, as well as the ease of substitution among inputs. Furthermore, Solow (1974) suggested that sustainability can be achieved with limited and non-renewable natural resources without cost of extraction and non-depreciating capital. Production uses capital and natural resources in which the substitution elasticity between the two inputs is one and certain technical conditions are met.

2.3. Growth Model with Resources and Technological Change

Technological change allows growth or at least constant consumption in dealing with a limited resource base. Growing the overall productivity factors makes sustainability technically easier and possible to achieve even its substitution elasticity is <1. The technological improvements imply that the source of production per unit will be higher in the future. The development of knowledge increases innovation in endogenous growth. As a result, the depletion of non-renewable resources is not optimal can be faster or slower. In the endogenous growth model of Aghion and Howitt (1998), technological change permits changes to one of the variables in the model and promotes economic growth.

The study of the role of resources in the growth model with endogenous technological changes is relatively limited (Smulders, 1999). Some models propose a very specific assumption for example, Smulders and De Nooij (2003) assumed that energy use has a positive growth rate regardless of the possibility of a reduction in the level its use. Moreover, Tahvonen and Salo (2001) shows the evolution of the use of energy sources from renewable energy to non-renewable energy and back to renewable energy in relation to economy. This model has extraction costs for fossil fuels and renewable energy production costs, which are increasing.

The relationship between energy consumption and economic growth has become a topic of many studies. The general view is that energy consumption can boost economic growth and the economic growth affectsthe energy consumption (Zhixin and Ren, 2011). The trend of the intensity of the energy use in the recent years has decreased because of technological changes, urbanization, and modernization, resulting in the decrease of the use of wood and replace it with the use of efficient and clean energy (UMEP, 2007). In general, economic growth causes the increase of energy consumption. Meanwhile, the relationship between energy consumption and GDP can be influenced by the substitution of energy and other inputs, technological changes, the shifting composition of energy source and the shifting of output composition (Stern and Cleveland, 2004).

In term of the relationship between energy consumption and energy growth, Senturk and Sataf (2015) have proposed four

hypotheses. The first one, growth hypothesis clarified that the energy consumption is a crucial component of the economic growth as they have direct relationship that leads to the economic growth. The more the energy consumption used the higher the economic growth will increase, but less the energy consumption used the more the negative effect of the economic growth will be.

The second one is conservation hypothesis which elaborates the indirect causal relationship between economic growth and energy consumption. This hypothesis implied that the economic growth affects the energy consumption. As a result, conservation policies regarding energy consumption will have little effect or will have not decimate the economic growth. Next, feedback hypothesis explains the existence of the interdependent relationship between the energy consumption and the economic growth. The energy consumption and the economic growth trigger and affect each other. The fourth is neutrality hypothesis stating that the energy consumption does not correlated with the economic growth. This hypothesis underlies that either conservative or expansive economic policy has no effect on the economic growth. Ozturk et al. (2010) found that there is a causal relationship between energy consumption and economic growth (GDP) in 51 European countries especially for low-and middle-income countries.

Meanwhile, Samuelson and Nordhaus (2010) stated that the rapid and continuous economic growth allows industrialized countries to provide something more to their citizens, such as better foods, bigger houses, more resources for health care, pollution control, universal education for children, and public pensions for retirees. Furthermore, Poveda and Martínez (2011) suggested that the increase of GDP and the supply of energy per capita decrease poverty and increase economic growth.

3. RESEARCH METHOD

The dependent variable of this study was economic growth and the independent one was the consumption of fossil energy and the renewable energy. The consumption of fossil energy (oil, coal and natural gas) is the sum of consumption issued by a country in a year andthe unit used was the percentage of the total energy consumption. The consumption of the renewable energy (solar energy, water, wind, and geothermal) is the sum of consumption issued by a country in a year and the unit used to measure the consumption of renewable energy is the percent of the total energy consumption.

Data used was secondary data derived from the World Bank and the International Energy Administrations report during 1995-2014. Meanwhile, the tool used to analysis the data is fixed effect model (FEM) or least square dummy variable with panel data method. This analysis tool was chosen as it was able to answer the objective of this study; therefore, the findings were expected to describe whether the consumption of fossil and renewable energy had a positive or negative influence on the economic growth. Based on the theoretical framework and the previous research, the model of this study is formulated as follows

$Q = f(K, L)$

$LnGDPit = \alpha_0 + \beta 1\ lnC_{it} + \beta 2 lnP_i + \beta 3 lnG_{it} + \beta 4 RENEW_{it} + D1 + D2 + D3 + D5 + u_{it}$

Note:
GDP: GDP constant data in 2005 (current 2005 US $).
C : The energy consumption of coal
Q : The energy consumption of crude oil (petroleum)
G : The energy consumption of natural gas
RNEW: Consumption of renewable energy
D1 : Dummy countries Brazil
D2 : Dummy countries Russia
D3 : Dummy country India
D5 : Dummy country South Africa
α0 : Intercept
β : Variable coefficients value
I : 1, 2, 3, 4, 5 (cross-section data of five BRICS countries)
t : 1, 2, 3., 18 (time-series data, 1995-2013)
ln : Natural logarithm
u : Error term

4. RESULTS AND DISCUSSION

After being estimated using FEM, the modeling panel data allowed each unit/country had its own intercept withassumptions variedamong units/state (cross-section). Meanwhile, based on the least square pooled method (panel data), the estimation results obtained by using FEM cross section is as follows.

Table 1 reveals that the result of the regression after being corrected using the Newey West-HAC was α = 5%, which meant thatthe variable of the energy consumption of coal positively and significantly affected the economic growth as the value of the t-statistic which was 6.071 wasgreater than that of t the table which was 1.660. The variable of α = 5% meant that the variable of petroleum energy consumption positively but not significantly affected the economic growth because the value of t-statistic = 0.799 was smaller than that of t-table value that was equal to 1.660. Meanwhile, using α = 5% the variable of energy consumption of natural gas positively but not significantly affected the economic growth for the t-statistic value = 0.985 was smaller than that of t-table that was 1.660. Moreover, using α = 5% the variable of renewable energy consumption positively but not significantly affectedthe economic growth because the value of t-statistic which was −2.38 was greater than that of t-table of 1.660. In dummy variables of D1, D2, D3 and D5, at the level of α = 5%,every dummy variable positively and significantly affected the economic growth because each of the variables had a value of t-statistic of 13.09, 3.70, 4.28, 6.40 respectively which were greater than that of t-table that was equal to 1.660.

The variable of the energy consumption of coal had a positive effect and was statistically significant to the economic growth in the five BRICS countries. The results of the regression showed that the coefficient of energy consumption of coal was 0.786, meaning that if the coal consumption rose 1%, economic growth will increase by 0.786%. The results of this study are consistent with existing theory stated that the energy consumption of coal has positive influence on the economic growth. The results were

Table 1: The regression result

Variable	Coefficient	Standard error	t-statistic
C	2.751317	0.520229	5.288663 (0.0000)*
lnC	0.786177	0.129485	6.071587 (0.0000)*
lnP	0.177090	0.221414	0.799811 (0.4259)
lnG	0.041386	0.042006	0.985251 (0.3271)
Renew	–0.013590	0.005695	2.386327 (0.0191)*
D1	4.243476	0.324016	13.09652 (0.0000)*
D2	1.117099	0.301679	3.702938 (0.0000)*
D3	0.367105	0.085772	4.280017 (0.0004)*
D5	2.585124	0.403813	6.401784 (0.0000)*
R-squared	0.992780		
Adjusted R-squared	0.992145		
F-statistic	7.927416		
Mean dependent variable	7.927416		
Standard dependent variable	0.845559		
Durbin Watson statistic	0.665051		

*Significant at α=5%

also consistent with the study of Lei et al. (2014) who claimed that the consumption of coal affectsthe economic growth in Germany, Russia, and Japan. The increase of the consumption of coal indicatesthe increase of the production activity that lead to the increaseof the economic growth. Xu et al. (2016) have also found that the increaseof the consumption of coal promotesthe economic growth in China.

The study of Gökmenoğlu and Taspinar (2016) in Turkey concluded that carbon emissions and FDI, energy consumption, and carbon emissions have a two-way causal relationship. On the other hand, there is a direct causal relationship from economic growth and energy consumption to FDI, and from economic growth to energy consumption. Meanwhile, Jalil and Feridun's (2014) pointed out that energy is one of the growth engines in China together with labor, capital, and international trade. A one percent increase in energy consumption leads to a 0.17% increase in GDP. Furthermore, Bildirici and Bakirtas (2014) found that in the long term there is a relationship between oil consumption and economic growth in all BRICS countries. Meanwhile, the relationship between coal consumption and economic growth is proven only in China and India; while, the relationship between natural gas consumption and economic growth is proven only in Brazil, Russia, and Turkey.

Moreover, Joo et al. (2015) showed that energy consumption can drive economic growth in Chile but not in vice versa. In addition, Chile relies on carbon energy consumption due to its rapid economic growth resulting in substantial CO2 emissions. This state indicated that Chile should make more efforts to develop energy-saving technologies and renewable energy sources to achieve green growth based on lower CO2 emissions.

In general energy use had a positive effect on economy. This condition is in accordance with the opinion of natural scientists and ecological economists who put a very important emphasis on the role of energy and its availability in the process of production and economic growth (Stern and Cleveland, 2004).

Furthermore, the estimation of the variables of petroleum energy consumption and natural gas energy consumption was positively correlated respectively, but statistically insignificant (Table 1). The result of this study was still in line with the existing theory stating that fossil energy consumption can positively affect economic growth. The insignificance of these two variables to economic growth could be attributed to the need of sufficient energy sources owned by BRICS countries, as well as the need of substantial cost in the process of its use. The result of this study supported the findings of Ozturk and Acaravci (2010) that there is no co-integration between energy consumption and real GDPper capita in Albania, Bulgaria, and Romania.

Meanwhile, the positive relationship between petroleum consumption and the economic growth is in line with the result of Sun and Seung (2014) who stated that the consumption of petroleum affects the economic growth in Malaysia, and furthermore, the consumption of oil affectsthe economic growth in short and long term. The increase in oil consumption can also create faster growth in GDP in both short and long term. The usefulness of oil can be easily measured by the authorities so that it can be used to stimulate the economy.

Other study by Behmiri and Manso (2014) indicates a causal relationship between petroleum consumption and the economic growth the Caribbean, Central America, and South America. In the long-term relationship test they did for the case of Caribbean and South America, the reduction of the petroleum consumption might become an appropriate instrumentfor the policy makers to do conservation of petroleum without causing any significant negative effect on the economic growth. However, in of Central America, the implementation of the petroleum conservation policies must be carefully conducted through the allocation of appropriate energy policy to reduce the negative impact on the economic growth.

Another finding of this study is that the positive relationship between the consumption of natural gas andthe economic growth is in line with the result of the study by Solarin and Shahbaz (2014). They identified that the consumption of natural gas has a positive effect on the economic growth in Malaysia. The consumption of natural gas also affects positively to the GDP growth in OECD countries (Destek, 2016).

The study of Çetintaş (2016) in 17 transition countries showed that there is a causal relationship from economic growth to energy consumption in the long-term. The results of Kaplan et al. (2011) also showedthat energy consumption and economic growth are two-way causality from energy consumption to economic growth and vice versa in Turkey. Energy is the limiting factor of economic growth, so the shock of energy supply has a negative impact on economic growth and vice versa.

The use of fossil energy that is capable of driving economic growth must keep environment sustainable as the result of the study of Castiglione et al. (2015) and Shahbaz et al. (2014) pointing

out the importance of regulation and law in the utilization of energy for economic growth while maintaining the environment preserves. The importance of having policies to reduce pollutants and of implementing environmentally friendly energy regulations sustainsthe economic development.

The variable of the renewable energy consumption as another result of this study contradicts the theory stated that this variable has a negative and significant impact on the economic growth at the level of $\alpha = 5\%$. Therefore, the results of this study indicate that in the countries of BRICS, when the consumption of renewable energy was massive, the GDP of these countries will be lower as the enormous costs are allocated to make use of renewable energy consequently, in the short term the positive impact has not shown its result yet.

This finding was in line with the one of Yazdi and Shakouri (2017) who stated that the consumption of renewable energy has a negative impact on economic growth in the short and long term in Iran. This finding implied that economic growth is favorable for the development of the renewable energy sector, which in turn helps boost economic growth in Iran's marginal role.

This result differs from the one of Naseri et al. (2016) who found that the increase of the consumption of the renewable energy positivelyaffect the economic growth in OECD countries. In Growth Hypothesis, energy is referred to a major factor in the production beside labor and capital. The increaseof the energy consumption might trigger an increase in production and economic growth.

Aslan and Ocal (2016) also identified that renewable energy has a positive impact on the economic growth in Bulgaria, Estonia, Poland, and Slovenia. The specialty of the renewable energy is low emissions of carbon dioxide that helps protect the environment, reducesthe dependence on foreign sources as a source of domestic energy contributes to an increase in employment and spur the economic growth in a country.

The study of Shakouri and Yazdi (2017) in South Africa showed that there is a two-way causality between renewable energy consumption and trade openness to economic growth. The empirical finding provide strong evidence that interdependence between renewable energy consumption and economic growth indicates that renewable energy is important for economic growth, as well as economic growth encourages the use of renewable energy sources. Tugcu (2012) identifies a two-way causality between renewable or non-renewable energy consumption and economic growth of G7 countries.

In the long term the use of renewable energy should be further developed because the nature of this energy can be renewed and its negative impact on the environment was relatively small. Countries should increase research and development (R and D) budgets to expand the use of renewable energy to maintain inclusive and sustainable economic growth.

Based on the estimation results, the regression model of each state is written as follows:

Brazil GDP = 6.99+(0.786) C+(0.177) P+(0.041) G-(0,013) R

Russia GDP = 3.86+(0.786) C+(0.177) P+(0.041) G-(0,013) R

India GDP = 3.11+(0.786) C+(0.177) P+(0.041) G-(0,013) R

China GDP = 2.75+(0.786) C+(0.177) P+(0.041) G-(0,013) R

Africa GDP = 5.33+(0.786) C+(0.177) P+(0.041) G-(0,013) R

The significance of the dummy variables used in the model shows that the economic growth of each country in five BRICS countries are different from the development of the China' economic growth used as a benchmark, as China has the largest economic growth rate compared to the other 4 countries. Meanwhile, the positive coefficient value and the smaller than $\alpha = 5\%$ probability within the entire value of the coefficient of the dummy indicate that the state represented by the dummy variable has different economic growth conditions from that of China.

The differences occurred may have been due to the differences in characteristics such as geography, social, cultural, economic structure, and system of government. The existence of the differences may affect the policy taken by each government of the BRICS countries to be wisely optimizedthe energy consumption to create sustainable development. Some countries have a strategic geographical location in which it gives an advantage in international trade. Besides, political and economic conditions would also affect the economic growth in each country. The political and economic conditions in the Central Asian countries influence the development or the economic growth (Senturk and Sataf, 2015).

Mercan and Karakaya (2015) analyzed the relationship between the energy consumption and the economic growth in OECD countries (Brazil, France, Greece, Italy, Republic of Korea, Mexico, Netherlands, Poland, Spain, Turkey, United Kingdom, and United States) selected as a representative of the development anddeveloping countries. The result showed that as each country has a different level of economic growth, the energy consumption negatively affect the economic growth in these countries.

The research result of He and Fu's (2014) confirmed that China is anexporter net carbon, China's exports are relatively less polluting than Chinese imports. The large carbon surplus contained in the trade is due to China's large-scale exports and high carbon emissions intensity compared to its trade. Stern and Cleveland (2004) showed that the energy used per unit of economic output has decreased, but is largely due to a shift from low-quality fuels such as coal with high-quality fuel use, and especially electricity. Furthermore, time series analysis showed that energy and GDP are co-integrated.

5. CONCLUSION

The relationship among energy consumption, institutions, and economic growth is very important and can affect each other. This paper discusses the effects of fossil energy consumption and

renewable energy on economic growth in BRICS countries. Based on the results of research and discussion, it can be concluded that:

1. The consumption of the fossil energy especially coal positively and significantly affect the economic growth in five BRICS countries
2. The consumption of the fossil energy especially oil and natural gas positively but statistically not significantly affect the economic growth in five BRICS countries
3. The consumption of the renewable energy has a negative effect on the economic growth in five BRICS countries.

This result is important for the governments of the BRICS countries to design the formulation and implementation of appropriate policies and strategies to encourage better use of energy to promote economic growth and reduce poverty.

In the future research, aspects suggested to be deepened are: (1) The type of energy; especially the use of expanded renewable energy, (2) the impact of energy use; especially the negative externalities of energy use on environmental sustainability, (3) regulations;laws and regulations on the use of environmentally friendly energy.

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