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Original Article

The Effect of Energy Sources and CO_2 Emission on Indonesia's Economic Growth in Different Regime

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Abstract: One of the country's economic development indicators is reflected in the country's economic growth. Objective: This study was conducted to examine the effect of the use of energy sources and CO2 emissions on economic growth in different regime in Indonesia. Data and Method: The data used are annual time series data published by World Development Indicators (WDI) database during the year 2004-2019.The data analysis method used is the ARDL regression approach model. Result: The results of the study found that CO2 gas emissions in the short and long term do not affect economic growth. The use of imported energy and energy use has a negative effect on economic growth in the short term. Meanwhile, in the long term, it has a positive effect on economic growth. Furthermore, this study found that renewable electricity output has a positive effect on economic growth in both the short and long term and renewable energy cons has no effect on economic growth in the short and long term. Finally, this study found that the difference between the regime of the SBY and JKW periods influenced economic growth.

Keywords: economic growth; energy; CO_2; Indonesia.

1. Introduction

One of the country's economic development indicators is reflected in the country's economic growth. In the Indonesian context, almost in the last two decades, economic growth has fluctuated economic growth in both the regime of Susilo Bambang Yudhoyono (SBY) and Joko Widodo (JKW). Economic growth is certainly influenced by various factors and one of the factors that makes economic growth promising is energy sources. Stern (2015) stated that the energy factor is very important for every country in increasing its economic growth. The importance of energy sources.

Haseeb et al. (2019) and Mardani et al. (2019) said that in order for policy makers in a country to think about directions and policies that lead to the excavation and exploration of new sustainable energy sources, policy makers need to think about it. Kahia et al. (2017) and Szustak et al. (2021) were share energy groups consisting of non-renewable energy (N-RE) sources and renewable energy (RE) sources. Thus, with the two energies are expected to be able to provide benefits to economic growth (Foxon, 2017). Although, the fossil energy is produces CO2 gas emissions which have an impact on environmental problems which lead to a decrease in a country's economic growth.

Many previous empirical research results show that the use of RE and N-RE or fossil energy is different (Gozgor et al., 2018). Antonakakis et al. (2017) found RE and N-RE had an effect on economic growth. Ito (2017) developing countries find the use of N-RE has a negative effect on economic growth. Paramati et al. (2017) using data from developing countries and developed countries from the G20 countries, found a relationship between the use of CO2 gas emissions, the use of RE and economic growth. Kasperowicz et al. (2020) in the Balkans and Black Sea Countries, stated that the use of N-RE has a positive effect on economic growth. Muhammad (2019) using data from the developed and developing countries group states that the use of gas emissions increases the use of energy consumption so as to increase economic growth except for MENA countries. Esen & Bayrak (2017) said that energy consumption has a positive effect on economic growth. Dogan (2016) in Turkey, found that NRE had no effect on economic growth while non-EBT had a significant effect on economic growth. (Haseeb et al., 2019) in Malaysia found that both the short and long term N-RE affect economic growth. Charfeddine & Kahia (2019) using MENA country data found that the use of EBT does not affect economic growth, but consumption of CO2 emissions tends to have a greater effect on economic growth.

Shahbaz et al. (2020) reveal that the consumption of RE from the use of electricity increases economic growth which has an impact on CO2 emissions and the environment. This makes the environment more unhealthy. Yang & Kim (2020) show that RE is associated with economic growth but not for countries that export RE facilities. (Ghazouani et al., 2020) said that environmental policies on the use of renewable electricity had an impact on accelerating economic growth in ASEAN countries. Apergis & Payne (2011) found a short and long term causal relationship use of renewable and non-renewable electricity with economic growth. Ibrahiem (2015) stated that the consumption of renewable electricity has a positive impact in the short and long term.

Mensah et al (2019) stated that N-RE consumption is related to economic growth both in the short and long term. (Zangoei et al., 2021) found that fossil fuels have an effect on gross domestic product. (Gokmenoglu & Sadeghieh, 2019) stated the the long term there is a negative relationship between carbon emissions and economic growth in Turkey. (Yapatake Kossele & Njong, 2020) found that there is no significant relationship between the use of N-RE and economic growth, so the use of RE does not limit the economic growth of a country. (Ahmad & Du, 2017) using Iranian data found that in the long term the use of CO2 gas emissions with economic growth and energy production affects economic growth. (Obradović & Lojanica, 2017) using data from countries in the South Eastern Europe (SEE) region, found that in the long term there is a causality of energy use and CO2 emissions on economic growth but not in the short term. Thus, this study was conducted to examine the Indonesia's economic growth and several influencing factors by adding era variables during the SBY and JKW regime as categorical variables. The reason for adding government era variables has its own unique variations in different circumstances and policies (Jamali et al., 2007); (Knutsen, 2021).

2. Materials and Methods

2.1. Data Source

The data used in this study are secondary data from published reports data.worldbank.org and data.imf.org for the 2004-2019 time period from World Development Indicators (WDI) database. The data documentation relates to economic growth, renewable electricity output, renewable energy consumption, energy imports, energy use and CO2 gas emissions. All the data is compiled and made in a time series data structure.

2.2. Data Analysis

This study employed the Autoregressive Distributed Lag technique to evaluate the data because it used time-series data. Before estimating ARDL, this study conducted tests regarding stationary, cointegration, bound test, normality, heteroscedasticity, autocorrelation, and linearity tests so that the ARDL model is more valid and consistent in estimation (D. N. Gujarati, 2003); (Pesaran et al., 2001). The ARDL model was carried out because of the potential for non-stationary explanatory variables. The use of ARDL produces consistent long-term coefficients (Falianty, 2003). On the other hand, the use of the ARDL model becomes more useful in econometrics where it makes economic theory from static to dynamic and takes into account time (Silalahi, 2020). And the ARDL approach can explain the response of explanatory variables in the short and long term to changes in the dependent variable (D. Gujarati & Porter, 2006). This study aims to describe the events that occur in economic growth in two different presidential positions. The dummy variable was entered to see the difference in economic growth in dummy 1 for 2004-2014 in the SBY era and dummy

0 for 2014-2019 during President Jokowi which influenced the research model. The ARDL equation for the dummy variable in the long run is as follows:

$$EG_{it} = \beta_0 + \beta_1 COE_{it} + \beta_2 EI_t + \beta_3 EU_t + \beta_4 REO_t + \beta_5 REC_t + \beta_6 D_1 + \varepsilon_i \quad (1)$$

As for the short-term dummy ARDL equation as follows:

$$\Delta EG_{it} = \beta_0 + \beta_1 \Delta(CO2)_t + \beta_2 \Delta(EI)_t + \beta_3 \Delta(EU)_t + \beta_4 \Delta(REO)_t + \beta_5 \Delta(REC)_t + \beta_6 \Delta(D_1)_t + \varepsilon_t \quad (2)$$

Model 1 and Model 2 describe that EG represents economic growth, CO2 represents the gas created when carbon-based materials are burned, and EI represents acquiring products and services from abroad. Sales of goods or services abroad are referred to as EU activities. REO is the electric output of power plants that use renewable resources, such as wind, solar PV, solar thermal, hydro, marine, geothermal, solid biofuels, renewable municipal waste, liquid biofuels, and biogas with the exception of fossil fuels Renewable energy consumption is measured as the ratio of gross inland renewable energy consumption to total (primary) gross inland energy consumption calculated for a calendar year; D is dummy of government; β0-β6 is the coefficient of all independent variables, is the error of this research model and t is the time period used in this study

3. Results and Discussion

3.1. Descriptive and test of stationarity, cointegration and classical assumption

Table 1 presents descriptive statistics of research variables. It is stated that the series (Economics growth, Co2 emission, energy import, energy use, renewable electricity output, renewable energy con) is normally distributed and is shown by the Jarque–Bera statistic. The high standard deviation value of all variables indicates that the data is spread around the mean and very broadly. Jarque-Bera results. confirm that the variables are normally distributed.

Table 1. Result of Descriptive Statistics

Items	Economic Growth (%)	Emission CO2 (kt)	Energy Import (% of energy use)	Energy Use (kg of oil equivalent per capita)	Renewable electricity output (% of total electricity output)	Renewable Energy Consumption (% of total final energy consumption)
Mean	5.456	430205	-82.481	829.700	12.708	39.050
Max	6.300	563325	-50.200	883.900	15.900	41.400
Min	4.600	33.7635	-112.300	788.100	10.700	36.900
SD	0.551	69125	17.556	30.256	1.183	1.289
JB	1.363	0.856	0.215	0.668	3.810	0.543
Prob	0.505	0.651	0.897	0.715	0.148	0.762

In addition, Table 1 above describes Indonesia's average economic growth of 5,456%, average CO2 emissions of 430205 kt. While the energy imported is still negative 82.481% compared to the energy used, the average energy used is 829,700kg. Furthermore, the average renewable energy output is 12.708% and the average Renewable Energy Consumption is 39.50%. Thus, it can be concluded that economic growth during the research period is promising, especially compared to the pandemic issue and global economic uncertainty predicted by the Indonesia Monetary Fund on average. All data used in this study came from the World Development Indicators (WDI) database.

In this study, the Augmented-Dickey-Fuller statistical stationarity test (ADF statistics) was used in the unit root test of time series data. This test is useful for estimating a more valid ARDL model so that the relationship between variables in this study becomes more stable and is not worried about false relationships in the Application of Autoregressive Distributed Lag (ARDL). In this study, the cointegration test was carried out using the bound testing cointegration method with the ARDL approach introduced (Pesaran et al., 2001).

Table 2. Stationary test

Variable	Stationary test	
Economic Growth	LEVEL	-2.763391*
CO2 emission	LEVEL	-2.139453
	DIFF	5,340028**
Energy import	LEVEL	-2.061612
	DIFF	-2.725600*
Energy use	LEVEL	-2.02185
	DIFF	-3,930464**
Renewable electricity outlet	LEVEL	-2.939140*
Renewable energy cons	LEVEL	-2.111541
	DIFF	-3,698923**

Note: *, **, ***, **** significant at 10%, 5%, 1%, and 0%.

Based on Table 2, the variables used in this study are stationary at the level and first different with Augmented-Dickey-Fuller statistics (ADF statistics). economic growth and renewable electricity output and stationary variables at the level level, while the variables CO2 emission, energy import, energy use and renewable energy are stationary at the first difference level. Because the variables are stationary at the level or first different, the cointegration test can be performed for the long-term relationship between the variables. Prior to the ARDL test, the Bound Test was carried out for the existence of a long-term cointegration relationship between variables in the study. In this study, the cointegration test was carried out using the bound testing cointegration method with the ARDL approach introduced (Pesaran et al., 2001).

Table 3Cointegration Test

F-Bounds Test	Value	significant	I(0)	I(1)
		10%	2.12	3.23
F-Statistics	12.34	5%	2.45	3.61
K	6	2.50%	2.75	3.99
		1%	3.15	4.43

This table reports the Bound test. H0 for time-series Bound test is that there is no cointegration within variables. *; **; and *** denote significant at 10%, 5%, and 1% respectively

Table 3 describes the output of the Bound test based on 6 different models. The F-statistical value of 12.34 shows that there is no significance level at 10%, 5%, 2.5% and 1% in the bound test. While the F value of 12.34 is greater than the upper limit (I (1)). These results indicate that the null hypothesis for all modals is rejected. This explains that there is a long-term cointegration for each model. Furthermore, testing the coefficient stability of the long-term relationship model using the cumulative sum (CUSUM) of the recursive residuals. CUSUM test results can be in the form of the following graph:

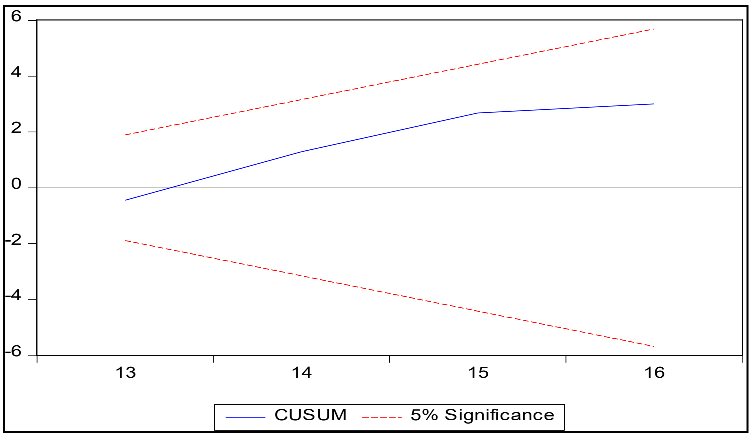

Figure 1. Stability Test Results

The CUSUM test results in Figure 1 show that the CUSUM test plots for the three models are within the critical limit of 5% significance, because the cumulative number is fixed and the residual variation is stable within the 95% confidence interval. This shows that the model in the study is not incorrectly determined and there is no sudden structural change in the model from time to time. It can be assumed that the coefficients of the model are stable and there is no structural break. From the previous diagnostic tests, it was proven that the ARDL model passed all the required tests. Thus, the model in this study can be used for the interpretation of long-term and short-term tests with the ARDL approach. This study uses a diagnostic test to validate the stability of the ARDL model so that it is suitable to be used in estimating the model because it provides valid, reliable and strong results. Table 5 below gives the results on the normality test, Heteroscedasticity test, Autocorrelation test and Linearity test.

Table 4. Classical Assumption Testing

Classical Assumptions	Test	Coeffs	Prob.
Normality test	Jarque Bera	0.332	0.847
Heteroscedasticity test	Breusch-Pagan-Godfrey: Obs. R-Square	9.981	0.189
Autocorrelation test	Breusch-Godfrey (BG) LM: Obs. R-Square	4.853	0.027
Linearity test	Ramsey Reset	0.723	0.425

Table 4 shows that the P value for the Jarque-Bera test is 0.69 > 5%. These results provide evidence that the data set is normally distributed. The Heteroscedasticity test has a prob value of 0.1896 which is greater than the 5% significance level, indicating that the model is free from heteroscedasticity. While the results of the Autocorrelation test using Breusch-Godfrey confirmed the prob value of 0.0276, which means the model used in this study is fit and statistically significant. The results of the linearity test using the Ramsey reset research model have been determined correctly as indicated by a probability value of 0.4258 which is not significant at 5%.

3.2 Short and Long-term ARDL Approach

Table 5 captures the short term and long-term CO2 emission does not significantly affect economic growth. This can be seen from the value of the CO2 coefficient which is not significant in both the short and long term. These results show that the carbon emissions produced by the Indonesian state in pursuing have not had a destructive effect on environmental damage and have not had an impact on economic growth. These findings contradict the research of Paramati et al. (2017) in G 20 countries, Ahmad & Du (2017) in Iran, Obradović & Lojanica (2017) in the SEE Region; and Mensah et al (2019) who all say CO2 gas affects economic growth.

As for the use of energy, both energy imports and energy use, this study finds that in the short term these two variables have a significant effect on economic growth. This can be seen from the value of short-term energy import efficiency - 0.0438 with a probability value of 1% or t-count and energy use - 0.6239 with a significance probability value of 1%. However, in the long run this study finds that energy imports and energy use have a positive effect on economic growth. This can be seen from the coefficient values of the energy import and energy use variables, which are 0.0269 and 0.0165, respectively, with a significant probability value of 1% and 5%.

This indicates that in order to pursue economic growth, Indonesia still has to use increased energy imports and energy use so that the rate of economic growth can be achieved. This means that in the short term the use of imported energy and energy use will reduce Indonesia's economic growth. So, in the Indonesian context, it is better to use this energy as carefully as possible and according to needs. This finding is in line with the research of (Muhammad, 2019) specifically for developed, developing and MENA countries; Azam & Raza (2022) focus on 11 Asian Countries; Esen & Bayrak (2017) countries that import energy in Europe; Szustak et al (2021) in European countries, where all of their research concludes that energy consumption from conventional energy including imports affects economic growth.

The results of renewable electricity output in Indonesia significantly positively affect economic growth both in the short and long term. This shows that the increase in the use of renewable electricity output also has an impact on the resulting increase in economic growth. The findings of this study are in accordance with the research of Gozgor et al (2018); Antonakakis et al (2017); Ito (2017); Kasperowicz et al (2020) and Haseeb et al (2019) which states that the use of renewable energy sources affects economic growth. The results of this study indicate that Indonesia has a significant source of renewable electricity. Renewable energy sources need to be studied and explored so that they can become useful and useful energy sources for the community and increase economic growth. Meanwhile, the use of variable renewable energy, both short term and long term, has not affected economic growth both in the short and long term.

Table 5. ARDL Testing, Short Run and Panel B Long Run

Panel A Short Run		
Variable	Coefficient	t-statistics
C	29,127	3.3641**

CO2 Emission	0.0000079	0.664
Energy Import	-0.0438	4.4472***
Energy Use	-0.6239	4.8436***
Renewable Electricity Output	0.2957	3.1001**
Renewable Energy Cons	-0.1633	1.1776
Dummy Regime	-1.0235	3.9954***
EG (-1)	-0.6299	-2.5083**
R-Squared	0.889	
Adj.R-Squared	0.7781	
Panel B Long Run		
CO2 Emission	0.00006	0.6792
Energy Import	0.0269	4.8758***
Energy Use	0.0165	4.3692***
Renewable Electricity Output	0.1814	0.0433**
Renewable Energy Cons	-0.1002	-1.112
Dummy Regime	0.6279	5.6899***

This is indicated by the coefficient value of -0.1633 in the short term and -0.1602 and has a probability value outside the significant level. The findings of this study indicate that the use of renewable energy cons in Indonesia has not been maximized so that it has not been able to increase economic growth. The results of this study are different from the research conducted by Charfeddine & Kahia (2019), which focuses on testing in the MENA area which states that the use of NRE has not been able to explain economic growth. The findings of this study indicate that the use of renewable energy cons in Indonesia has not been maximized to be utilized so that it has not been able to increase economic growth. The results of this study are different from the research conducted by Charfeddine & Kahia (2019) in the MENA area which states that the use of NRE has not been able to explain economic growth. The findings of this study indicate that the use of renewable energy cons in Indonesia has not been maximized to be utilized so that it has not been able to increase economic growth. The results of the dummy variable show that economic growth in the short term of the SBY era has increased by 1.0235 compared to the era of President Joko Widodo. Meanwhile, in the long term, the SBY era increased by 0.6279. The results of this study are in accordance with research conducted by Jamali et al (2007) who found that political regime affect economic growth in more than 57 countries, Jamali et al (2007) and Knutsen (2021) which states that stable government has an impact on the economy of a country.

4. Conclusions

On the basis of ARDL testing that has been carried out in the short and long term. This study found that CO2 emission does not have a significant impact on economic growth in the short and long term. Meanwhile, the variables of energy import, energy use and renewable energy cons have a negative impact on economic growth. While, renewable electricity output has a positive impact on economic growth. These results show the differences in the regime of President SBY and President Jokowi that both in the short and long term produce differences in economic growth in Indonesia.

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