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Dynamic Effects of Energy Consumption on Economic Growth in an Emerging Economy

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ABSTRACT

The main objective of this research is to investigate the dynamic effects of energy consumption on economic growth in the Indonesian context. Based on the annual data of 1990-2017, the empirical ARDL model presents significant effects of energy use, electric power and renewable energy consumption on economic growth. The analysis using error correction model presents the long-run effect of energy use on economic growth. In the short-run, the electric power consumption and labor participation rate have a positive effect on economic growth. The variable of energy use has symmetric effects both in long and short-term periods. The electric power and renewable energy consumption have asymmetric effects in the long-and short-run models. This paper highlights that energy consumption and labor force are the main sources of economic growth in this country. It implies that the research findings are in line with the neoclassical economic theory.

Keywords: Economic Growth, Energy Use, Renewable Energy
JEL Classifications: O47, O13, O52

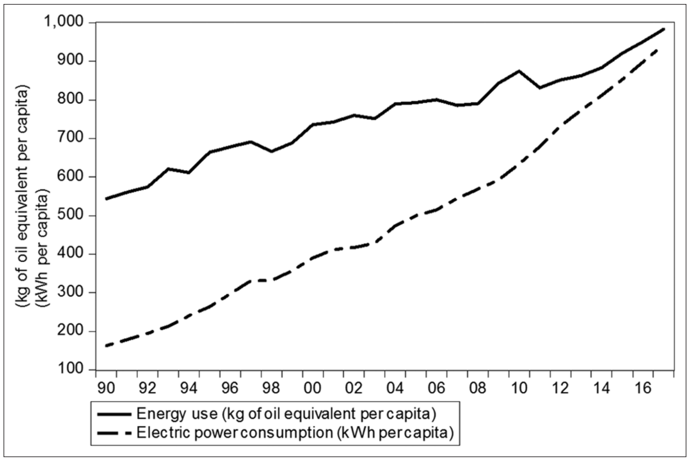
1. INTRODUCTION

The issue of energy consumption has become the main topic of discussion in Indonesia for a long time. It relates to its impact on the economic development process in all sectors such as household activities, industry development, transportation, services, and other sectors. More than half of energy consumption in this country is used by industrial sector which has a major contribution to economic growth. Therefore, the role of energy consumption on economic growth needs more attention. Some previous studies provide the analysis results of the relationship between energy consumption and economic growth in various countries (Dahmardeh et al., 2012; Kao and Wan, 2017; Karhan, 2019; Zeshan and Ahmed, 2014). Most of these papers confirm the positive impacts of energy consumption on economic growth.

For three decades starting from 1990, the energy consumption in Indonesia has significantly increased. Figure 1 presents the level of energy use and electric power consumption for this period. The electric power consumption increases for about 500%, meanwhile energy use level rises double along 30 years. The energy use level is more volatile than the electric power consumption as an impact of global oil price changes. Although the industrial sector uses large amounts of electricity, the household sector also contributes to the sharp increased in electric power consumption. It may be inferred that these two sectors play a very important role in economic activities in the country. Another component of energy consumption that has important effects on the development process in Indonesia is renewable energy consumption. Contrary to energy use and electric power consumption, renewable energy consumption for about 30 years has declined as presented in Figure 2. The figure clearly illustrates the data of renewable energy consumption which decreased by about 20% since 1990. It may indicate the low commitment of the government on the issue of renewable energy development.

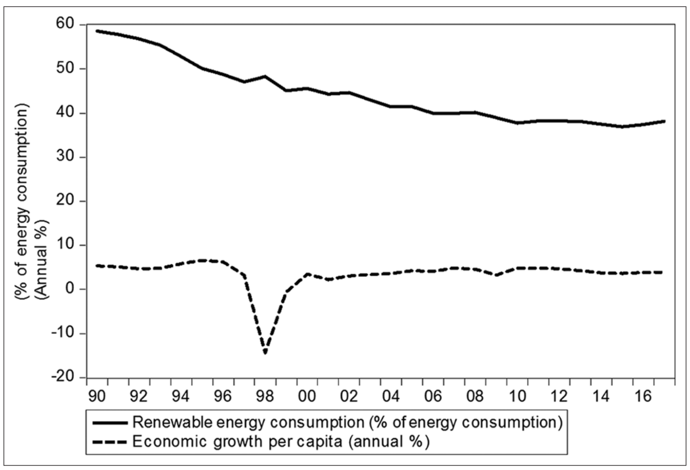
As illustrated in Figure 2, the economic growth per capita in Indonesia for the period of 1990-2017 was quite stable. It dropped

Figure 1: Energy use and electric power consumption



Source: https://data.worldbank.org

Figure 2: Renewable energy consumption and economic growth



Source: https://data.worldbank.org

at about -14% in 1998 as an impact of depth monetary crisis which attacked almost all Asian countries. After successful recovery in 3 years, at about 10 years the economic growth is stable at around 5% annually. The unexpected global financial crisis in 2008 which started from European countries also affected the domestic economic situation. It gave pressure on the economic growth level which declined about 1% from the previous year. Relating to these three kinds of energy consumption data, we may infer that energy use and electric power consumption have a positive association with economic growth per capita. Although the data of renewable energy consumption show the decreasing for the long period, in the last 5 years it tends to increase. We consider that renewable energy consumption may also contribute to economic growth in the country. Therefore, it is important to analyze the impact of energy consumption as well as renewable energy consumption on economic growth in Indonesia.

It was limited paper which examined the impact of energy consumption on economic growth for Indonesia context in the last years. However, a study presents the findings relating to the role of energy consumption on economic growth with the object of selected Asian countries including Indonesia (Dahmardeh et al., 2012). Another hand, the most recent paper by Nugraha and Osman, (2018) analyzed the relationship between energy consumption and economic growth for the Indonesian case. However, this study only involves final energy consumption variable as a determinant of economic growth that may remain some weaknesses in the empirical model. Therefore, our research aims to analyze the effect of various variables regarding energy consumption on economic growth. In this study, we also include investment and labor force which are assumed as the main economic growth determinants in the model. Moreover, we consider the fiscal and monetary variables to elaborate on the role of government policies in supporting economic growth. We expect that this paper contributes to the literature of energy use and consumption as well as its effects on economic growth at the national level. Such research on the Indonesian case may be useful for other countries regarding energy management and policy to achieve optimum economic growth.

2. RELATED LITERATURE

Some previous studies have examined the impact of energy consumption and other economic factors on economic growth in some countries. However, these studies found various results from each other which certainly be used as an appropriate reference for this research. Several papers focus on the relationship between energy consumption and economic growth (Farabi et al., 2019; Dahmardeh et al., 2012; Kao and Wan, 2017; Paramati et al., 2018; Karhan, 2019; Zeshan and Ahmed, 2014, Ozturk, 2010). Other studies also elaborate on the impact of government policy including fiscal and monetary policies on economic growth (Bošnjak, 2018; Butkiewicz and Yanikkaya, 2011; Tule et al., 2018). Moreover, the analysis of the determinants of economic growth should include its fundamental variables such as capital and labor (Ali et al., 2018; Rafat, 2018; Srinivasan et al., 2011).

The papers which focus on the role of energy consumption on economic growth presents different results (Bashir et al., 2019; Dahmardeh et al., 2012; Kao and Wan, 2017; Karhan, 2019; Zeshan and Ahmed, 2014). The main finding of these studies highlights a strong relationship between energy consumption and economic growth. A causality relationship between these variables are found in Taiwan and ten other Asian developing countries (Dahmardeh et al., 2012; Kao and Wan, 2017). These studies mention that energy which is used in many sectors have a significant contribution to economic development. It implies that energy consumption potentially encourages higher economic growth in these some countries. In this situation, energy consumption directly increases economic growth through various economic activities. However, Kao and Wan (2017) note that the impact of energy consumption on economic growth also depends on the regime. As part of energy development, renewable energy consumption will be a focus of many countries to substitute fossil energy in the future. For example, Karhan (2019) and Soava et al. (2018) found that renewable energy has a positive impact on economic growth in European countries. These results indicate the political will of the countries on renewable energy development in the last three decades.

The analysis of the relationship between energy consumption and economic growth in Indonesian was conducted by Nugraha and Osman (2018). This study concludes the presence of the unidirectional relationship from energy consumption to economic growth. However, this study only involves one variable as a determinant of economic growth that is final energy consumption. Some previous research that focuses on economic growth determinants generally mentions several variables such as capital, labor, natural resources and government policies (Bošnjak, 2018; Černohorská, 2018; Hodula and Pfeifer, 2018). Based on these studies, we may highlight that economic growth is affected by various variables such as energy consumption, fiscal and monetary policies. Moreover, the government should maintain economic growth as an important indicator of macroeconomic performance at a desirable level.

The studies regarding the role of capital and labor as the factors of economic growth have been intensively conducted in recent years (Ali et al., 2018; Alvarado et al., 2017; Butkiewicz and Yanikkaya, 2011). These studies found that investment and human resources quality are important factors of economic growth in various countries. Moreover, Ali et al. (2018) employ independent variables such as foreign direct investment, gross domestic investment, and life expectancy ratio as a proxy of human capital in the economic growth model. The findings reveal the significant effect of those three variables on economic growth in China. The study also presents the asymmetric relationship between foreign direct investment and economic growth indicating China's government concerned on the outward foreign direct investment. On another hand, Alvarado et al. (2017) found that foreign direct investment is not adequate to accelerate economic growth in developing countries.

Other studies also elaborate on the impact of government policy including fiscal and monetary policies on economic growth (Bošnjak, 2018; Butkiewicz and Yanikkaya, 2011; Tule et al., 2018). The inclusion of the aspects of fiscal and monetary variables in the economic growth model is to explore the role of the political will of the government through various policies. Fiscal policy in Indonesia is expected to boost economic growth through subsidy policies on energy. Meanwhile, the monetary policy represents the political will of the central bank in creating a situation that supports the prospective investment in the country.

In order to obtain useful and applicable research for economic development in Indonesia, the investigation that considering energy consumption and other factors should be applied. This study is expected to provide scientific contribution which can be used as a reference in the literature of public economics. Moreover, the research findings may contribute to the energy development policies in Indonesia. We assumed that the energy-economic growth relationship in Indonesia is different from other countries. Therefore, the current study has uniqueness and some advantage of the inclusion of various variables in the model. The research also applied the asymmetric approach to capturing the response of examined variables on economic growth.

3. DATA AND METHODOLOGY

3.1. Data Description

This study analyzes the dynamic effects a number of economic variables namely investment (inv_t), labor participation rate (lpr_t), energy use (eu_t), electric power consumption (epc_t), renewable energy consumption (rec_t), money supply (ms_t), and government expenditure (ge_t) on economic growth (eg_t) for Indonesia's annual time series data 1990-2017. All the data are collected from annual reports of World Development Indicators (https://data.worldbank.org). The definition and the unit of each variable, as well as descriptive statistic indicators of all variables, are presented in Table 1.

3.2. Model Specification

The basic theoretical framework for analyzing economic growth is generally focused on a neoclassical growth model. The model states that the level of production is determined by two main factors namely capital and the labor force. This model has been broadly applied in empirical research on economic growth in various countries (Alvarado et al., 2017; Habibi and Karimi, 2017; Rafat, 2018). The initial model of economic growth may be represented in a standard Cobb–Douglas production function which is formulated in the many alternative econometric equations. However, in some empirical evidence, the neoclassical is extended to capture the effect of not only capital and labor force variables, but also other factors, such as investment, energy, exports, government policies, and other factors associated with the internal and external factors of an economy. Assuming the analysis of economic growth for time series data of the country is a function of capital, labor, and other factors; then the model can be expressed as follows:

$$y_t = F(K_t, L_t, Z_t) \quad (1)$$

Where y_t is a country's real economic growth rate in period t, K_t and L_t are capital and labor in period t, Z_t represents a set of other variables related to economic growth. Based on this theoretical framework, the current research estimates economic growth model with three alternatives set of independent variables as expressed by Model (2), Model (3) and Model (4).

Table 1: Descriptive statistic of the variables

Variables	Mean	Maximum	Minimum	Standard deviation
eg_t (annual %)	3.469	6.564	−14.346	3.743
inv_t (% of real GDP)	28.447	35.336	17.093	5.722
lpr_t (% of population)	66.593	68.870	63.310	1.343
eu_t (kg of oil equivalent per capita)	759.036	983.231	543.704	117.850
epc_t (kWh per capita)	490.488	943.326	162.502	230.682
rec_t (% of total final energy consumption)	44.370	58.597	36.879	6.843
ms_t (% of real GDP)	44.851	59.860	36.001	6.611
ge_t (% of real GDP)	8.383	9.749	5.693	1.116

Source: World development indicators, 1990-2017 (https://data.worldbank.org). GDP: Gross domestic product

$$eg_t = f(inv_t, lpr_t) \quad (2)$$

$$eg_t = f(inv_t, lpr_t, eu_t, epc_t, rec_t) \quad (3)$$

$$eg_t = f(inv_t, lpr_t, eu_t, epc_t, rec_t, ms_t, ge_t) \quad (4)$$

3.3. Estimation Framework

This study analyzes the dynamic effects a number of economic variables on economic growth. The standard cointegration approach is used to examine the long-run relationship between economic growth and other variables. For this purpose, we use the linear Autoregressive Distributed Lag (ARDL) model which is considered good for small samples (Pesaran et al., 2001). It also may be applied even the examined variables have a different order of integration such as I(0) and I(1). The general form of equation linear ARDL of order (p,q) which captures the relationship between y_t and x_t may be written as follows:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \ldots + \beta_p y_p + \delta_1 x_{t-1} + \ldots + \delta_q x_q + \varepsilon_t \quad (5)$$

The ε_t is the disturbance term that is serially uncorrelated with zero means and constant variance-covariances. This assumption is similar to the stationarity condition for an AR(1) process and implies that there exists a stable long-run relationship between y_t and x_t. If λ =1, then there would be no long-run relationship between dependent and its regressor variables. For a case of the ARDL (p_1, q_1) model approach to cointegration testing is expressed as:

$$\Delta y_t = \eta_0 + \lambda_1 y_{t-1} + \lambda_2 x_{t-1} + \sum_{i=1}^{k} \alpha_1 \Delta y_{t-1} + \sum_{i=1}^{k} \alpha_2 \Delta x_{t-1} + \upsilon_t \quad (6)$$

The Δ means first difference, y_t and x_t are the I(0) or I(1) variables, v_t is serially uncorrelated disturbances with zero means and constant variance-covariances. Coefficients λ_i correspond to the long-run effects meanwhile, α_i represents the short-run dynamic of the model. The optimum lag length (k) may be determined using information criteria such as Schwarz criterion (SC).

Based on Equation (6), we may test the possibility of the presence of a cointegrating relationship among the variables using a standard Bound test. The F-statistic is applied to the joint null hypothesis that the coefficients of the lagged variables (y_{t-1} and x_{t-1}) are zero. The null hypothesis of the non-existence of the long-run relationship is defined by *Ho: λ1=λ2=0* against the alternate hypothesis of *Ha: λ1≠λ2≠ 0*.

The next step is to analyze the dynamic responses of explanatory variables on economic growth. We used a standard Nonlinear Autoregressive Distributed Lag (NARDL) model to elaborate on the possibility of asymmetric effects of independent variables. The asymmetric NARDL model includes the partial sum decompositions in constructing the long-run and short-run relationship (Shin et al., 2014). Therefore, we assume the long-run relationship of data series y_t and x_t as the following asymmetric regression:

$$y_t = \phi^+ x_t^+ + \phi^- x_t^- + v_t \quad (7)$$

The y_t is the dependent variable, x_t is a (k×1) vector of the independent variable, and v_t is the error term. The coefficient ϕ^+ and ϕ^- denote the related asymmetric long-term parameters. Here, the variable x_t is decomposed into two components x_t^+ and x_t^-. These components are the partial sum of process positive (+) and negative (–) changes in x_t, which are defined as follows:

$$x_t^+ = \sum_{i=1}^{t} \Delta x_i^+ = \sum_{i=1}^{t} \max(x_i, 0) \quad (8)$$

$$x_t^- = \sum_{i=1}^{t} \Delta x_i^- = \sum_{i=1}^{t} \min(x_i, 0) \quad (9)$$

Following Shin et al., (2014), the asymmetric error correction model relating to the Equation (2) in NARDL (p,q) model is:

$$\Delta y_t = \rho y_{t-1} + \theta^+ x_{t-1}^+ + \theta^- x_{t-1}^- + \sum_{j=1}^{p-1} \delta_j \Delta y_{t-j} + \sum_{j=0}^{q} (\pi_j^+ \Delta x_{t-j}^+ + \pi_j^- \Delta x_{t-j}^-) + \varepsilon_t \quad (10)$$

The ε_t is error term, $\theta^+ = -\rho\phi^+$ and $\theta^- = -\rho\phi^-$. The terms p and q indicate the number of lag length for the dependent and independent variables respectively. The optimum lag length of this model may be determined using information criteria such as Schwarz criterion (SC).

Equation (10) exhibits the asymmetric relationship between variable y_t and x_t which contains a component of positive and negative changes of the independent variable. This study elaborates not only the dynamic effects of the number of economic variables on economic growth but also the multiplier effects of each independent variable. Therefore, we consider estimating the empirical model of economic growth (eg_t) as a function of each independent variables namely investment (inv_t), labor participation rate (lpr_t), energy use (eu_t), electric power consumption (epc_t), renewable energy consumption (rec_t), monetary policy (ms_t), and fiscal policy (ge_t) in different equations respectively. The asymmetric cumulative dynamic multipliers which capture the adjustment process from short-run disequilibrium to its long-run equilibrium are formulated as follows:

$$m_k^+ = \sum_{j=0}^{k} \frac{\delta y_{t+j}}{\delta x_t^+}, k = 0,1,2..... \quad (11)$$

$$m_k^- = \sum_{j=0}^{k} \frac{\delta y_{t+j}}{\delta x_t^-}, k = 0,1,2..... \quad (12)$$

Where m_k^+ and m_k^- are multiplier effects of positive and negative changes of independent each variable. As $k \rightarrow \propto$, m_k^+ and m_k^- tend to be equal with the asymmetric long-run coefficient ϕ^+ and ϕ^- respectively.

4. EMPIRICAL RESULTS AND DISCUSSION

The estimation process of the ARDL model which is part of the dynamic analysis procedure requires a stationary test of the data. However, this model may be applied to the set of variables which have a different order of integration. The ARDL model should not be applied for the data series which are stationary in the second difference. The results of the unit root test of the examined variables using Augmented Dickey-Fuller (ADF) are presented in Table 2. For the small sample data in this analysis, we conduct a stationary test on data series with intercept and optimal lag length based on Schwartz Criterion. The results reveal that three variables, eg_t, lpr_t and rec_t, are stationary. Meanwhile, the other variables have a unit root at the level. It may be inferred that all variables are also stationary at the first difference.

The estimates results of the ARDL model based on Model (2), Model (3) and Model (4) are presented in Table 3. We follow the general-to-specific approach of ARDL which the estimation process starts by choosing the max lag length and dropping all insignificant lags. The first model is the empirical model of economic growth as a function of capital and labor participation rate. These two variables are statistically significant at least at 10% level of significance. The results confirm the neoclassical theory of economic growth for the Indonesian case. The second model, economic growth is the function of not only capital and labor participation rate, but also energy use, electric power consumption, and renewable energy. Energy consumption has a significant effect at one lag. Variable of electric power consumption significantly affect economic growth at the second lag. Meanwhile, renewable energy consumption affects economic growth in the same period. Finally, the inclusion of monetary and fiscal variables does not imply the different results. It means that government policies have no effect on economic growth based on this model.

Since this study concern the dynamic effects of independent on dependent variables, it is important to present the cointegration test. We conduct the cointegration test using Bound test procedure in which the results are presented in the lower panel of Table 3. The F-statistic rejects the null hypotheses of no co-integrating relationship among the set of variables even at 1% significance level. It implies the presence of a long-run relationship in a set of series variables for all models. As the consequence of the presence of this long-run relationship, we are able to conduct the analysis of long and short-run dynamic effects such as using an error correction model.

Table 4 presents the results of long and short-run analysis based on error correction model from the ARDL estimation (Equation 6). In the long-run model, it is only energy use that significantly affects economic growth with a coefficient of 0.15. It implies the increase of energy consumption at 1 kg per capita leads to the increase of economic growth at 0.15%. In the short-run, the positive changes in the labor participation rate and electric power consumption have

Table 2: Results of the unit root test

Variables	Level		First difference	
	t-Statistics	P-value	t-Statistics	P-value
eg_t	−3.77	0.002	−6.65	0.000
inv_t	−1.84	0.352	−3.49	0.015
lpr_t	−4.03	0.004	−5.27	0.000
eu_t	−1.52	0.507	−5.85	0.000
epc_t	0.71	0.999	−3.02	0.044
rec_t	−3.78	0.008	−5.16	0.000
ms_t	−1.81	0.366	−3.16	0.033
ge_t	−1.34	0.595	−5.05	0.000

The optimal lag is based on the Schwartz Criterion (SC). All data series in level contain unit root except eg_t and rec_t. All the first difference data series are stationary

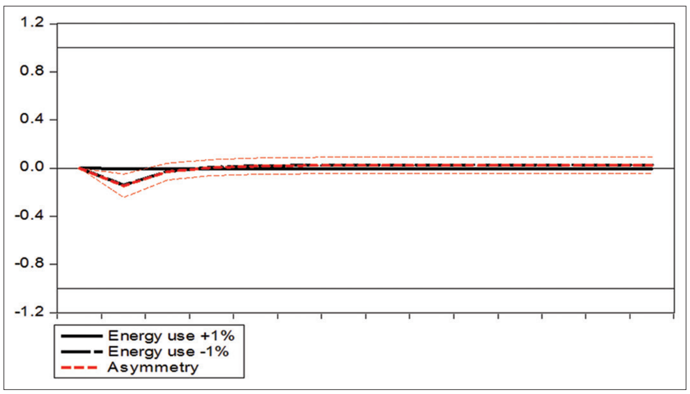
Table 3: Results of ARDL estimates

Variables	Model (2)		Model (3)		Model (4)	
	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
Constant	−54.73	−1.91*	−125.19	−2.26**	−261.03	−1.66
eg_{t-1}	−0.12	−0.59	0.03	0.14	−0.17	−0.59
inv_t	1.17	3.68***	−0.07	−0.22	0.71	1.41
inv_{t-1}	−1.05	−3.63***	0.55	1.10	−0.53	−1.39
inv_{t-2}			−0.84	−2.25**		
lpr_t	0.82	1.91*	1.34	1.81*	1.77	1.26
lpr_{t-1}			1.94	2.71**	2.27	1.92**
lpr_{t-2}			−2.32	−4.96***	−3.10	−3.43***
eu_t			−0.02	−1.00	−0.04	−1.07
eu_{t-1}			0.04	1.82*	0.12	2.92**
eu_{t-2}			0.02	1.16	0.09	2.19**
epc_t			0.01	0.64	−0.21	−1.44
epc_{t-1}			−2.22	−3.83***	0.36	1.83*
epc_{t-2}			1.57	2.56**	−0.19	−1.81*
rec_t			1.28	2.33**	−4.05	−3.48***
rec_{t-1}			0.03	0.14	3.46	2.78**
rec_{t-2}			−0.07	−0.22	1.72	1.79
ms_t					0.38	0.52
ge_t					2.41	1.11
ge_{t-1}					3.08	0.77
ge_{t-2}					−4.37	−1.48
R^2	0.47		0.79		0.93	
F-statistic	5.14***		4.14***		4.41**	
SC	5.39		4.98		5.29	
F-statistic (bound test)	10.13***		11.88***		4.68***	

The results are based on ARDL cointegrating and long run estimation with a maximum lag length of 2 lags based on Schwarz Criterion (SC). *,**,*** Indicate significant at 10%, 5% and 1% significance level, respectively. F-statistic bound is from the co-integration test an effect of economic growth at the next period. The one lag of energy use has a negative impact on economic growth. Meanwhile, the changes in renewable energy consumption have a negative impact on economic growth in the same year. The findings imply the changes of economic growth depend on the labor force and electric power consumption. On another hand, the changes in energy consumption and renewable energy consumption did not increase economic growth.

The extension analysis of this study is to elaborate on the asymmetric response of the economic growth determinants. Based on the NARDL as expressed by Equation (10), the coefficients of long and short-run asymmetric response of eu_t, epc_t, erc_t, and lpr_t are presented in Table 5. We do not present the other explanatory variables as the consequence of the insignificant in the previous estimates. The coefficients of θ^+ and θ^- indicate the long-run effects of the independent variables on economic growth. Meanwhile, the coefficients of π^+ and π^- represent the dynamic responses of the changes of the independent variables on changes of economic growth. Based on the t-test procedure, all coefficients are statistically significant even at 1% level. Therefore, we conclude that the responses of energy use on economic growth are symmetry in long and short-run. With the same procedure, the responses of electric power and renewable energy consumption on economic growth are asymmetry in the long and short-run period. Meanwhile, the labor participation rate has an asymmetric relationship with economic growth only in the short-run. Specifically, these findings reveal the presence of asymmetric response of asymmetric effects of energy consumption on economic growth.

Figure 3: Dynamic multiplier of energy use (eu_t) on economic growth (eg_t)



Comparing with other literature regarding the research in the area of energy economics and policy, these findings are in line with many studies such as Dahmardeh et al. (2012), Karhan (2019), Nugraha and Osman (2018) and Zeshan and Ahmed (2014). Moreover, this paper completes the previous studies by providing asymmetric responses to the effects of energy consumption on economic growth. This paper reveals the asymmetric responses of energy use on economic growth. On another hand, the responses of electric power and renewable energy are asymmetry. The significant impact of electricity power consumption on economic growth also similar to the previous findings such as Rehman and Deyuan (2018) and Oshota, (2014). The electricity power dominates the energy sources in all economic sectors in Indonesia including households, industry, and also services. At the limited amount,

Table 4: Short and long-run effects of explanatory variables

Short-run effects			Long-run effects		
Variables	Coefficient	t-stat	Variables	Coefficient	t-stat
$dinv_t$	0.71	1.41	*Constant*	−221.96	−1.95*
$dlpr_t$	1.77	1.26	inv_t	0.15	0.37
$dlpr_{t-1}$	3.11	3.43***	lpr_t	0.81	0.58
deu_t	−0.04	−1.07	eu_t	0.15	2.78***
deu_{t-1}	−0.09	−2.19***	epc_t	−0.03	−0.85
$depc_t$	−0.21	−1.44	rec_t	0.96	0.84
$depc_{t-1}$	0.19	1.80*	ms_t	0.32	0.55
$drec_t$	−4.06	−3.48***	ge_t	0.95	0.16
$drec_{t-1}$	−1.72	−1.78			
dms_t	0.38	0.52			
dge_t	2.41	1.11			
dge_{t-1}	4.37	1.48			
$CointEq_{t-1}$	−1.17	−3.95***			

The results are based on error correction estimation from ARDL model with a lag length of 1 lag based on Schwarz Criterion (SC). *,**,***Indicate significant at 10%, 5% and 1% significance level, respectively

Table 5: Short and long-run asymmetric effects of selected explanatory variables

Coefficient	Effects of eu_t: Short and long-run symmetry		Effects of epc_t: Short and long-run asymmetry		Effects of rec_t: Short and long-run asymmetry		Effects of lpr_t: Short-run asymmetry	
	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
θ^+	0.08***	6.41	−0.01***	−2.48	3.71*	1.61	−1.11	−1.59
θ^-	−0.51***	−6.75	0.67	0.81	0.474	1.31	−0.85	−1.56
π^+	0.08***	17.90	0.15***	2.86	−8.16***	−4.45	−1.09	−1.53
π^-	0.76***	12.04	0.49	0.80	0.343	1.37	1.32*	1.68

The estimation is based on the asymmetric model with a lag length of 1 lag based on the Schwarz Criterion (SC). *,**,*** indicate significant at 10%, 5% and 1% significance level, respectively

Figure 4: Dynamic multiplier of electric power consumption (epc_t) on economic growth (eg_t)

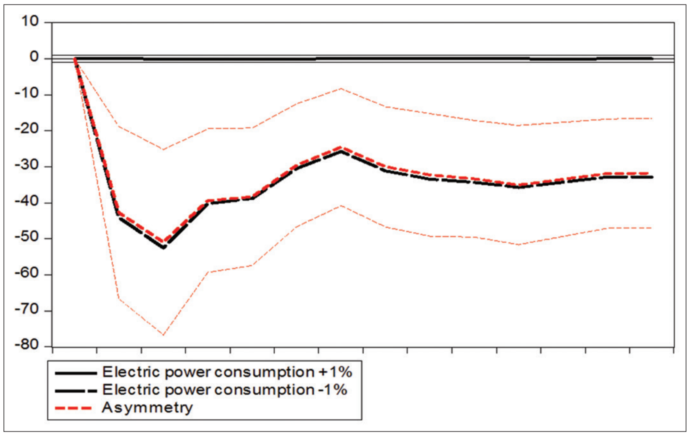


Figure 5: Dynamic multiplier of renewable energy consumption (rec_t) on economic growth (eg_t)

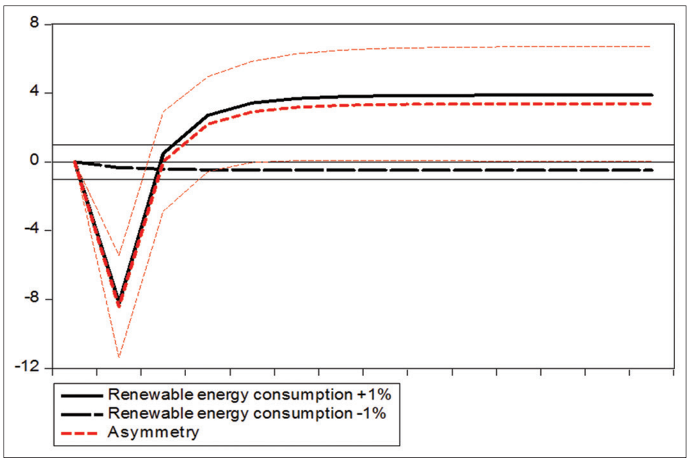
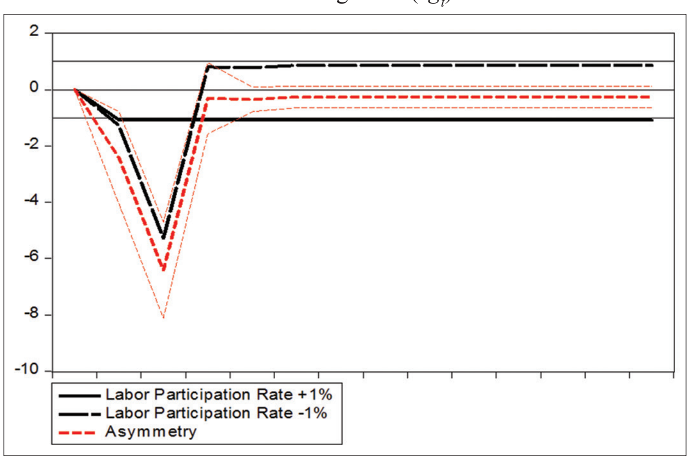


Figure 6: Dynamic multiplier of labor participation rate (lpr_t) on economic growth (eg_t)



Indonesia has developed renewable energy in around provinces. This is the acceptable reason that the impact of renewable energy consumption on economic growth requires time lags.

The next analysis is to present the dynamic multipliers of each explanatory variable on economic growth in the graphical form. The results of each variable are presented in Figures 3-6. The dynamic effects of positive and negative changes in energy use on economic growth are presented in Figure 3. It indicates the low gap between positive and negative changes in energy use on economic growth. After the 2nd year, it shows the low symmetric responses of energy use on economic growth. Figure 4 describes the asymmetric responses of the effects of positive and negative changes in electric power consumption on economic growth. For the long period, the positive changes in electric power consumption have a negative impact on economic growth. Focusing on the variable of renewable energy consumption, the effect of its positive components on economic growth causes lower growth in the short run, but it has a positive effect in the long-run (Figure 5). Finally, this section also presents the dynamic multiplier of labor participation rate on economic growth which is depicted in Figure 6. The positive changes in this variable have a positive effect on economic growth after 2 years. In the short-run, the positive changes in the labor participation rate have a negative effect on economic growth.

5. CONCLUSION

The objective of this research is to investigate the dynamic effects of capital, labor force, energy consumption, and government policies on economic growth in the Indonesian context. Based on the time series data of 1971-2017, this study concludes that the main factors of economic growth are energy use, electric power consumption, and labor participation rate. The estimates of the error correction model present that energy use variable has a positive impact on economic growth only in the long term period. Meanwhile, the changes in electric power consumption and labor participation rate affect the economic growth in the short-run model. The renewable energy consumption has a negative impact on economic growth indicating that the energy development policy has not been optimum yet.

Based on the ARDL model, this research finds a significant role of investment and labor of participation rate variables indicating the confirmation of the neoclassical economic growth model. Overall, the inclusion of the energy use, electric power and renewable energy consumption in the basic model are statistically significant. On the other hand, the involvement of monetary and fiscal variables in the complete model is insignificant. It implies that the government policy has not supported energy development for the period of examination.

It is also important to present the asymmetric responses of various variables of energy consumption on economic growth. The variable of energy use has symmetric effects both in long and short-term periods which are indicated by the significance of its positive and negative components in the empirical model. It means that the increase in energy use causes higher economic growth, the lower energy use will reduce the economic growth rate. Meanwhile, the electric power and renewable energy consumption have asymmetric effects on economic growth implying that only positive changes may affect economic growth. This paper highlights that energy consumption and labor force are the main sources of economic growth in this country. This paper recommends the central government to increase the investment for energy industry development in the future.

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