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Causal Relationship between Electric Consumption and Economic Growth in South East Sulawesi

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ABSTRACT

This study aims to investigate the causal relationship between electric consumption and economic growth in Southeast Sulawesi. Time series of electric consumption and per capita regional gross domestic product data in the period of 1985–2016 were used in this study. The causal relationship were examined using an autoregressive distributed lag model and Granger causality test. The tests revealed a strong positive causal relationship between electric consumption and economic growth of South East Sulawesi in the long-run. Each 1% increase in electric consumption would caused 0.31% increase in economic growth. In the short-run, however, weak relationship exists between electric consumption and economic growth. Hence, electric consumption contributes to economic growth of Southeast Sulawesi in the long-run and in the short-run.

Keywords: Electric Consumption, Economic Growth, Autoregressive Distributed Lag Model, Granger Causality
JEL Classifications: C120, C320, E2, E210

1. INTRODUCTION

Indonesia is oil producing country, despite the fact that the volume of production doesn't meet the domestic demand. One of the roles of oil in Indonesian economic is as input for electric industry (Adam et al., 2018; Muthalib et al., 2018). It is not surprising that oil is used in most of electric generators in Indonesia including in Southeast Sulawesi. Increase in oil price might cause increase in expenditure for electric consumption. As electric power is vital for goods, service, transport industries as well as for households, increase in electric consumption by industries and households might affect other economic variables including economic growth.

Relationship between energy consumption (electric consumption) and GDP (economic growth) can be explained using four hypotheses (Ozturk, 2010). Firstly, neutral hypothesis which explains that no relationship exist between electric consumption and GDP. Secondly, conservative hypothesis which explains that one way relationship exists from economic growth to energy consumption. Therefore increase in economic growth will increase energy consumption. Thirdly, growth hypothesis which explains that one way relationship exists from energy consumption to economic growth. In this situation, limiting the energy consumption might has negative impact on economic growth while increase in energy consumption might contribute to economic growth. Fourthly, feedback hypothesis which explains that two way relationships exists between energy consumption and economic growth, which means change in energy consumption might cause change in economic growth, vice versa.

Numerous researches in the literature have investigated the relationship between electric consumption and economic growth in various countries, resulted in inconsistent conclusions.

Inconsistencies of the researches results might be resulted from: Differences in data bundle being used in the researches, differences in econometric methodology applied, and differences in characteristics of countries under researches. Country specific characteristics might be in terms of: Energy supplies, social political situation, institutional characteristic, and cultural characteristic (Ozturk, 2010). Despite the inconsistencies of researches results, the literatures supports empirical researches results regarding hypotheses explaining relationship between electric consumption and economic growth; e.g., (1) No relationship exists between electric consumption and economic growth (Murray and Nan, 1996); (2) Electric consumption influences economic growth (Amusa and Leshoro, 2013); (3) one way relationship exists from economic growth to electric consumption (Iyke, 2014); and (4) two way relationship exists between electric consumption and economic growth (Tang, 2008).

Moreover, researchers have studied the relationships between electric consumption and economic growth in Indonesia, such as Yoo (2006) who investigated the relationship between electric consumption and economic growth in four of ASEAN countries (Malaysia, Indonesia, Singapore, and Thailand). He concluded that, among others, economic growth affects electric consumption in Indonesia. According to our best knowledge, however, relationship between electric consumption and economic growth in Southeast Sulawesi, as one of provinces of Indonesia, has never been investigated. The objective of this study therefore is to test the causal relationship between electric consumption and economic growth in Southeast Sulawesi. We used the autoregressive distributed lag (ARDL) model and Granger causality test.

2. LITERATURE REVIEW

This subsection outlined literature reviews of several results of empirical researches on the relationship between electric consumption and economic growth conducted in various countries. Literature searching resulted in two groups of empirical researches on relationship between electric consumption and economic growth in various countries: Researches investigating only one country, and research investigating more than one country. Literature review revealed that subjects of the researches are not limited to relationship between electric consumption and economic growth, but also investigating relationship between the two variables (electric consumption and economic growth) and other economic variables such as export, oil production, demand for internet and remittance.

Kraft and Kraft (1978) research in USA motivated the subsequent researches on relationship between electric consumption and economic growth. They revealed one way relationship from GNP to electric consumption. Polemis and Dagoumas (2013) investigated the relationship between electric consumption and economic growth in Greece using cointegration test and vector error correction (VECM) model to analyze data ranged from 1970 to 2011. The test resulted in the two way relationship between electric consumption and economic growth. Subsequently, they ended up with conclusions that Greece is dependent on energy, and energy conservation policy should be directed toward increasing economic growth. Kasperowicz (2014) investigated the relationship between electric consumption and economic growth in Poland using quarterly data ranging from 2000 to 2012, revealed that Granger causality tests revealed one way relationship from electric consumption to economic growth. He concluded that electric consumption is one of limiting factors to the economic growth of Poland.

Research by Makun (2015) using the VECM model and Granger causality test to analyze time series data of period 1981–2011 resulted in conclusion that in the long-run relationship exists from electric consumption to economic growth. He concluded that in the long-run electric consumption is essential for economic growth and development in Fiji so that the government needs to allocate new energy resources and to lower energy import for electric generating facilities. Mahmoudinia et al. (2013) studied causal relationship among oil production, electric consumption and economic growth in Iran using the ARDL model and Granger causality test in the analysis of data ranged from 1973 to 2006. They revealed that in the long-run one way negative relationship exists from oil production and electric consumption to economic growth.

Bayar and Ozel (2014) studied the relationship between electric consumption and economic growth of emerging economies countries (Brazil, Chile, China, Colombia, Czech Republic, Egypt, Greece, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Peru, Philippines, Poland, Russia, South Africa, Taiwan, Thailand, and Turkey) in the period of 1970–2011. Analysis and test using causality panel, i.e., Granger causality, resulted in existence of two way positive relationship between electric consumption and economic growth of emerging economies. The greatest effect of electric consumption on economic growth is happened in Hungarian countries. Wolde-Rufael (2006) studied the long-run causal relationship between electric consumption and economic growth of African countries (Algeria, Benin, Cameroon, Congo-DR, Congo-Rep, Egypt, Gabon, Ghana, Kenya, Morocco, Nigeria, Senegal, South Africa, Sudan, Tunis, Zambia, and Zimbabwe). Toda and Yamamoto causality test, a modified version of Granger causality test was used to analyze time series data of the period of 1971–2001. The test resulted in no causal relationship between electric consumption and economic growth in five countries (Algeria, Kenya, South Africa, Republic of Congo, and Sudan), positive causal relationship from GDP growth to electric consumption in six countries (Cameroon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe) and existence of one way relationship from electric consumption to growth of GDP in the rest of the countries under research.

Kirikkaleli et al. (2018) studied the link between electric consumption, internet demand and economic growth of 35 OECD countries, i.e. Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. They used fully modified ordinary least squares (FMOLS), dynamic ordinary least squares (DOLS) and Dumitrescu-Hurlin causality panel to test the long-run relationship. Analysis using FMOLS and DOLS methods revealed that in the long-run link exist between electric consumption, internet demand and economic growth. However, Dumitrescu-Hurlin causality test revealed the following causality relationships: (1) Two way relationships exists between electric consumption and internet demand, and; (2) one way relationship exists from economic growth to electric consumption. Hossain (2012) investigated dynamic causal relationship between economic growth, electric consumption, export and remittance in the following countries: Bangladesh, India and Pakistan using Granger causality panel. Granger causality test using data ranging from 1976 to 2009 revealed two way short-run relationship between economic growth and export, and long-run relationship between economic growth, electric consumption and remittance.

3. DATA AND METHODOLOGY

3.1. Data

Two time series data ranging from 1985 to 2016 are used, i.e., electric consumption and per capita regional gross domestic product (RGDP), and electric consumption in Southeast Sulawesi. Per capita RGDP is the proxy for economic growth. Unit of measurement of per capita RGDP is Indonesian Rupiah (IDR). Electric consumption is also measured in IDR, since electric consumption is approached by the total expenditure for electricity, i.e., amount of kilo watt hours (Kwh) consumed multiplied by price per Kwh.

Yearly time series data obtained from Statistical Bureau of the province of Southeast Sulawesi. Per capita RGDP and electric consumption variables are in the form of natural logarithm and labeled as GRO and CON respectively for analytical purposes.

3.2. Methodology

Method used for testing the causal relationship between electric consumption and economic growth is referred to testing method applied by Ozturk and Acaravci (2016) where cointegration relationship in the long-run and short-run were tested using the ARDL bound test developed by Pesaran and Shin (1999), and Pesaran et al. (2001). Meanwhile, causality relationship test was conducted using the VECM model where each of equations in the model is the ARDL - error correction model (ECM). The causal relationship test model is then called Granger causality test. Causal relationships consist of: (1) Short-run causal relationship, also known as weak causal relationship; (2) long-run causal relationship; and (3) strong long-run causal relationship.

Advantage of the ARDL bound cointegration test is that variables involved in the model do not need to be integrated in the same order as required in Johansen cointegration test. Therefore, all of regressors can be in the process of I(0), I(1) or combination of both. However, each of variables involved in the model should not be in the process of I(2). Stationary test for variables was conducted to ensure that none of variables involved in the model is in I(2) process.

The first step of the analysis is therefore the stationary test or integration order test (also known as unit root test) to all variables. Stationary test used in this study is Augmented Dickey-Fuller (ADF) stationary test developed by Dickey and Fuller (1979) and Phillips-Perron (PP) test developed by Phillips and Perron (1988). The null hypothesis of the two unit root tests are H_0: The time series has unit root (times series is not stationary); and the alternative hypothesis H_1: Time series doesn't has unit root (time series is stationary).

The second step is cointegration test between research variables, i.e., between electric consumption and per capita RGDP (GRO). Cointegration test used in this paper is, as mentioned earlier, the ARDL bound cointegration test, for testing the long-run relationship between CON and GRO in the following regression model specification:

$$GRO_t=\alpha+\beta CON_t+\varepsilon_t \quad (1)$$

Where α and β are regression parameters (β is also called long-run coefficient), and ε_t is error at the time t. Values of parameters α and β are:

$$\alpha=\frac{C_1}{1-\sum_{i=1}^{p}\alpha_{1i}} \text{ and} = \beta\frac{\sum_{j=0}^{q}\beta_{1j}}{1-\sum_{i=1}^{p}\alpha_{1i}} \quad (2)$$

Where C_1, α_i (i = 1, 2, …p) and β_j (j = 0, 1, 2, …q) are parameters of the ARDL(p,q) model with equation, as follows:

$$GRO_t = C_1+\sum_{i=1}^{p}\alpha_{1i}GRO_{t-i}+\sum_{j=0}^{q}\beta_{1j}CON_{t-j}+\varepsilon_{1t} \quad (3)$$

Where ε_{1t} is error or white noise that is identical distributed and independently with mean 0 and homoscedastic. Coefficients in (2) can be obtained, if variables GRO and CON are stable in the long-run. Subsequently, equation (3) is also called long-run equation of The ARDL model about the relationship between CON and GRO, if cointegration relationship between CON and GRO exist. The ARDL bound cointegration equation is as follows:

$$D(GRO_t)=C_2+\sum_{i=1}^{p-1}\alpha_{2i}D(GRO_{t-i})+$$
$$\sum_{i=1}^{p-1}\alpha_{2i}D(GRO_{t-i})+\sum_{i=1}^{p-1}\alpha_{2i}D(GRO_{t-i})+$$
$$\sum_{j=1}^{q-1}\alpha_{2i}D(CON_{t-j})+\theta_1 GRO_{t-1}+$$
$$\theta_2 CON_{t-1}+\varepsilon_{2t}$$

Where C_2, α_{2i} (i = 1, 2,…, p−1,) β_{2j} (j = 0, 1, 2,…, q-1), θ_k (k = 1,2) parameters of regression equation, and ε_{2t} is white noise. Null hypothesis of ARDL bound cointegration test is H_0: θ_k = 0 (CON and GRO are not co-integrated), while alternative hypothesis is H_1: $\theta_k \neq$ 0, k = 1, 2 (CON and GRO are co-integrated). Statistical test used for hypothesis testing is Wald-statistics or F-statistics. In addition, long-run coefficient test, and classical assumption test of residual (autocorrelation test, normality test, and homoscedasticity test) were also conducted to evaluate the ARDL (p,q) model in equation (3).

The third step in the analysis is testing the long-run and short-run relationships between CON and GRO using equation (2) and ECM with the following equation

$$D(GRO_t) = C_3 + \sum_{i=1}^{p-1} \alpha_{3i} D(GRO_{t-i}) + \sum_{j=0}^{q-1} \beta_{3j} D(CON_{t-j}) + \delta EC_{t-1} + \varepsilon_{3t} \quad (5)$$

Where C_3 α_{3i} I = 1, 2,…, p-1), β_{3j} (j = 0, 1, 2,…, q-1), and δ are parameters of regression equation, and ε_{2t} is white noise. Time series EC_{t-1} is error correction time series resulted from equation (1).

The fourth step is testing the causal relationship between CON and GRO using the VECM model with the following equation:

$$\begin{pmatrix} D(GRO_t) \\ D(CON_t) \end{pmatrix} = \begin{pmatrix} C_4 \\ C_5 \end{pmatrix} + \sum_{i=1}^{p} \begin{pmatrix} \pi_{11,i} & \pi_{12,i} \\ \pi_{21,i} & \pi_{22,i} \end{pmatrix} \begin{pmatrix} D(GRO_{t-i}) \\ D(CON_{t-i}) \end{pmatrix} + \begin{pmatrix} \psi_1 \\ \psi_2 \end{pmatrix} EC_{t-1} + \begin{pmatrix} \varepsilon_{4t} \\ \varepsilon_{5t} \end{pmatrix} \quad (6)$$

Where $\begin{pmatrix} C_4 \\ C_5 \end{pmatrix}$ is constant matrix, $\begin{pmatrix} \pi_{11,i} & \pi_{12,i} \\ \pi_{21,i} & \pi_{22,i} \end{pmatrix} (i = 1,2,\ldots,p)$ and $\begin{pmatrix} \psi_1 \\ \psi_2 \end{pmatrix}$ are coefficient matrix, whereas $\begin{pmatrix} \varepsilon_{4t} \\ \varepsilon_{5t} \end{pmatrix}$ is white noise matrix. As mentioned previously, there are three types of causal relationship according to the equation, i.e.: (1) Short-run causal relationship or weak Granger causal relationship (Masih and Masih, 1996; Asafu-Adjaye, 2000; Ozturk and Acaravci, 2016). The short-run relationship of this type can be determined by evaluating significance of all parameters $\pi_{jk,i}$), (j,k = 1, 2) and (I = (1, 2,…,p) using t-statistics test (Koop, 2013) or F-statistics test or Wald-statistics test (Ozturk and Acravci, 2016); (2) long-run causal relationship, which can be determined by evaluating significance of parameters ψ_j (j = 1, 2) using *t*-statistics test or Wald-statistics test (Masih and Masih, 1996; Ozturk and Acaravci, 2016); and (3) Strong Granger causality which can be detected by evaluating joint significance of coefficients $\pi_{jk,i}$ and ψ_j (Asafu-Adjaye, 2000; Lee and Chang, 2008; Ozturk and Acaravci, 2016).

4. RESULTS AND DISCUSSION

4.1. Results

Estimation results of statistical tests of ADF and PP are listed in Table 1, separated into constants without trend and with trend. Some of test statistics for variables CON, D(CON) and D(GRO) are significant at 1%. Therefore, electric consumption variable is I(0) process, while per capita RGDP is I(1) process.

The second step is cointegration tests between CON and GRO using the ARDL bound test with cointegration equation in (4). A test for determining the time lag was however conducted prior to estimating equation (4). Based on information criteria Akaike Information Criterion, the ARDL (6, 2) model obtained. Residual of the ARDL (6, 2) model is independent (no autocorrelation), normally distributed, and homoscedastic. Autocorrelation, normality and homoscedasticity test were conducted using the following tests: Breusch-Godfrey Serial Correlation test, Jarque Berra test, and ARCH test, resulted in respective statistics as follows: 0.1113, 0.479576 and 0.1147. Plot results for CUSUM and CUSUM Square tests for stability of the ARDL (6, 2) model coefficients using Brown et al. (1975) also resulted in stable coefficients as depicts in Figure 1. Subsequently, F statistics of estimation test is 366.0146. Meanwhile, upper bound critical value I (1) at 1% significance is 7.84. Comparing the two statistics results in conclusion that electric consumption variable and per capita RGDP variable are cointegrated, which means that long-run relationship exists between electric consumption and per capita RGDP (economic growth).

The third step is testing the short-run and long-run coefficient using ECM model in equation (5). Estimation results of coefficients summarized in Table 2 shows that all variables and constants are significant at 1% significance, except for coefficient of D(CON(-1)) variable which is significant at 10% significance. Therefore, in short-run and long-run, electric consumption affects economic growth. The long-run effect is positive, where 1% increases in electric consumption increases economic growth of 0.31%. Moreover, the short-run effect of electric consumption to economic growth is positive for time lag is 0. Negative value of coefficient EC(-1) indicates the long-run deviation of research variable is corrected around 0.76% for each of period of time to return to the long-run equilibrium.

Since estimation result of the ECM model shown in Table 2 doesn't provide any information on causal relationship, the next step is therefore estimating the coefficients of equation (6) to determine the direction of causal relationship. Statistics in Table 3 revealed that: (1) In the short-run, weak causal relationship exists from electric consumption to economic growth; (2) in the long-run, causal relationship exists from electric consumption to economic growth; (3) in the long-run, strong causal relationship exists from

Table 1: Unit root test

Variable	ADF test statistics		PP test statistics	
	Without trend	With trend	Without trend	With trend
CON	−1.6111	−5.2426*	−2.5184	−5.2418*
D (CON)	−6.1443*	−6.0255*	−27.8966*	−27.4035*
GRO	−0.6506	−2.2502	−2.2838	−1.5304
D (GRO)	−6.8549*	−4.9482*	−5.6322*	−8.2536*

*Represents significant statistics test estimates at 1% significance. Source: Own processing, ADF: Augmented Dickey-Fuller, PP: Phillips-Perron

Table 2: Estimation of short-run and long-run coefficients

Constant and variable independent	Coefficient	t-Statistics	P-value
Panel A : Short-run coefficient. Dependent variable: D (GRO))			
D (GRO(−1))	−0.2220*	−5.6844	0.0000
D (GRO(−2))	−0.2360*	−6.2527	0.0000
D (GRO(−3))	−0.2762*	−7.5216	0.0000
D (GRO(−4))	−0.2757*	−7.4635	0.0000
D (GRO(−5))	−0.2673*	−7.2581	0.0000
D (CON)	0.1364*	4.9676	0.0001
D (CON(−1))	−0.0530**	−1.9430	0.0698
EC(−1)	−0.7558*	−24.0452	0.0000
Panel B: Long-run coefficient. Dependent variable: GRO			
CON	0.3115*	7.3223	0.0000
C	10.5726*	13.1543	0.0000

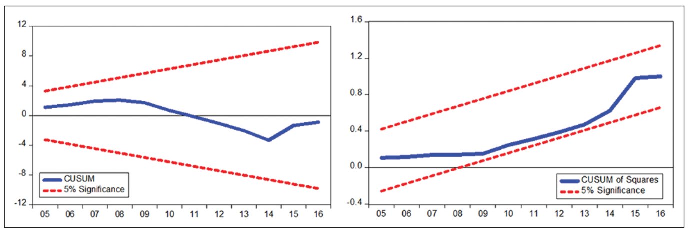
*,**Represent significant at 1 1% and 10% respectively. Source: Own processing

Table 3: Granger causality test or The VECM model

Independent variable, constant and granger causality	Dependent variable: D (GRO)		Dependent variable: D (CON)	
	Coefficient	t-statistic	Coefficient	t-statistic
C	1.634247*	4.377164	1.195461	0.289136
D (GRO(−1))	0.012136	0.072703	−0.502902	−1.223345
D (GRO(−2))	0.001966	0.011832	−0.383439	−0.937980
D (GRO(−3))	−0.057173	−0.345784	−0.267740	−0.694104
D (GRO(−4))	−0.064782	−0.390264	−0.160416	−0.474156
D (GRO(−5))	−0.072948	−0.439823	−0.049870	−0.193202
D (CON(−1))	−0.607234*	−3.749532	−0.068962	−0.128342
D (CON(−2))	−0.482550**	−2.761763	0.022685	0.048599
D (CON(−3))	−0.367221***	−2.110096	0.034268	0.073399
D (CON(−4))	−0.257401	−1.617689	−0.030371	−0.064963
D (CON(−5))	−0.134553	−1.087586	−0.039217	−0.109209
EC(−1)	−0.656336*	-4.711274	0.388011	1.016618

*,**,***Represent significant variable's coefficients at 1%, 5%, and 10% respectively. VECM: Vector error correction

Figure 1: CUSUM test graph and CUSUM of Square test graph



Source: Own processing

electric consumption to economic growth; and (4) no significant causal relationship exist either in the short-run or long-run, run from economic growth to electric consumption.

4.2. DISCUSSION

Result of cointegration test suggested that long-rung relationship exists between electric consumption and economic growth in Southeast Sulawesi. Results of the ARDL model, the VECM model and Granger causality tests suggested that in the long-run, the relationship is one way positive from electric consumption to economic growth, which means electric consumption contributes to economic growth. Each 1% of increase in electric consumption associated with 0.31% increase in economic growth. The positive long-run relationship is consistent with the growth hypothesis that increase in electric consumption can contribute to economic growth. This finding is parallel with the findings of Yoo (2006), Makun (2015), Bayar and Ozel (2014), and Wolde-Rufael (2006). Moreover, in the short-run, the weak positive relationship from electric consumption to economic growth is revealed for time lag is 0.

This research didn't find one way relationship of economic growth on electric consumption, either in the short-run or in the long-run, which contradicted conservative hypothesis. Hence, electric consumption in Southeast Sulawesi doesn't dependent on economic growth. This finding is inconsistent with the finding of Kirikkaleli et al. (2018) where economic growth can cause change in electric consumption. The discrepancy might be resulted from time span of data used in the analysis, social political situation and economic situation of the countries under research (Ozturk, 2010).

5. CONCLUSION

The objective of this research is to study the causal relationship between electric consumption and economic growth in Southeast Sulawesi. In order to achieve the objective, yearly time series data was collected, consisted of electric consumption and per capita RGDP where per capita RGDP is the proxy for economic growth. Time series data used in the research is ranging from 1985 to 2016. The ARDL bound model, the VECM model and Granger causality test were used to test the causal relationship.

Results of cointegration test suggested that long-run relationship exists between electric consumption and economic growth in Southeast Sulawesi. Meanwhile, results of VECM and Granger causality test results suggested that in the long-run, a strong positive relationship exists from electric consumption to economic growth. Each 1% in electric consumption led to 0.31% increase in economic growth. Subsequently, a weak short-run causal relationship is also found from electric consumption to economic growth.

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