Electricity Consumption and Gross Regional Domestic Product Nexus in Kalimantan Selatan Province: Cointegration and Causality Analysis

Karina Shella Putri*, Hafidz Noor Fikri

Mining Engineering Study Program Universitas Lambung Mangkurat, Banjarbaru 70714, South Kalimantan, Indonesia
**Corresponding author email: karinashella@ulm.ac.id*

ABSTRACT. This paper examines the direction of the long-run and short-run causality between electricity consumption and real GRDP in South Kalimantan Province. The time series used in testing is annual data from 2000 to 2018. The analysis of cointegration shows that electricity consumption and GRDP do not have a long-run nexus. The results of Granger causality analysis show that in the short term, there is a bidirectional causality from GRDP to electricity consumption and electricity consumption to GRDP. It explains that the GRDP is a variable that affects the amount of electricity consumption in South Kalimantan Province. The economic growth will have an impact on increasing electricity consumption. Besides, electricity consumption itself is also a variable that influences the fluctuation in GRDP. So that in the short term, the efficiency of electricity usage or the reduction of electricity consumption through demand-side management will affect the economic sectors that are directly related to the formation of GRDP in South Kalimantan Province. However, in the long run, the efficiency in electricity consumption will not affect economic growth in the province of South Kalimantan. So, in the long run, energy conservation policies in South Kalimantan Province can be implemented.

Keywords: *Granger causality, time series, economic growth, energy conservation.*

1. INTRODUCTION

South Kalimantan Province is a location for producing and processing mining products, including coal and iron sand, as well as the development of oil palm plantations, which has made the economy of South Kalimantan Province grow positively. Based on data from BPS of South Kalimantan Province (Badan Pusat Statistik Provinsi Kalimantan Selatan), favorable economic conditions can see from the economic growth of 5.28% per year from 2000 to 2018. When viewed from electricity consumption based on PLN Statistics, South Kalimantan Province experienced growth in electricity consumption by 6.87% per year from 2000 to 2018, even though negative consumption growth occurred in 2015 (-20.39%) and 2018 (-8.09%).

The Government of the Republic of Indonesia since 2009 has issued an energy conservation policy (PP No. 70/2009). The implementation of conservation policies certainly has different impacts at the regional level because the direction of causality between energy consumption and economic growth varies from region to region. If there is causality from energy consumption towards economic growth, then the application of energy conservation policies can harm economic growth.

Chen et al. (The Relationship Between GDP and Electricity Consumption in 10 Asia Countries, 2007) state that four possibilities can occur in causality. First, the uni-directional causality from electricity consumption to economic growth. Limited use of electricity can harm economic growth. Second, uni-directional causality from economic growth to electricity consumption means that economic growth will encourage the use of electrical energy, also efforts to conserve electricity utilization will not harm economic growth. Third, bidirectional causality, which means that the two economic variables are interrelated. The last, there is no causal relationship, which means that electricity consumption and economic growth do not correlate. The conservation policy and expansion of electricity supply have no impact on economic growth.

There are two groups of theories regarding the relationship between energy consumption and economic growth. The first group based on the neo-classical point of view states about the neutrality hypothesis, namely, the economic growth variable of a country is not bound to the energy consumption variable so that the application of

energy conservation policies will not reduce economic growth. Murry and Nan (1996), Yoo (The Causal Relationship between Electricity Consumption and Economic Growth in the ASEAN Countries, 2006), and Yoo, Kim (Coal Consumption and Economic Growth in Indonesia, 2016) prove that Indonesia is under this hypothesis where the causality that occurs is that GDP affects energy consumption but not vice versa. In detail, according to Murry and Nan (1996) (multi-country study), using the standard Granger causality testmethod in the data from 1970-1990 produced that causality in Indonesia is uni-directional where GDPaffects the consumption of electricity in the short term. Similar study results were also found by Yoo (The Causal Relationship between Electricity Consumption and Economic Growth in the ASEANCountries, 2006) in a multi-country study but were long-run while the short-run showed no causality. Based on a single country study conducted by Yoo, Kim (Coal Consumption and Economic Growth in Indonesia, 2016) using the Hsiao's version of Granger causality method in 1971-2002 data, not only did GDP affect the increase in electricity consumption uni-directionally but also influenced the increase in electricity generation. Suryanto (Suryanto, 2013), using the Granger causalitymethod and the Toda-Yamato procedure (Statistical inference in vector autoregressions with possibly integrated processes, 1995), concluded that therewas no causality between the GDP and electrical energy consumption variables and the adoption of electric energy conservation policies had no negative consequences on economic growth. He used the 1970-2010 Indonesia data. Sartika (2016), in a single country study in Indonesia in 1992- 2014 data using the causality granger test method, concluded uni-directional GDP affects the consumption of electrical energy so that the neutrality hypothesis is accepted.

The second group provides a theory in the form of a growth hypothesis that economic growth is strongly influencing by energy consumption, where energy is one of the factors of production so that the application of energy conservation can also inhibit economic growth. This view was agreed upon by Chen et al. (The Relationship Between GDP and Electricity Consumption in 10 Asia Countries, 2007), using the error correction model and granger causality test, namely causality in Indonesia is a uni-directional causality where GDP is influencing by long-term energy consumption.The same thing show by a multi-country study from Asafu-Ajaye (The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries, 2000) in 1973-1995 data using the Engle-Granger method. Fatai et al. (Modelling the causal relationship between energy consumption and GDP in New Zealand, Australia, India, Indonesia, The Philippines and Thailand, 2004), in a multi-country study comparing Australia and New Zealand to 4 Asian countries, shows that uni-directional causality where GDP influence by energy consumption generated by mathematical simulations of granger causality occurs in Indonesia. Chiou-Wei et al. (Economic growth and energy consumption revisited—Evidence from linear and nonlinear Granger causality, 2008), with the Linear Granger causality method, produces uni- directional causality where GDP is influenced by energy consumption while the nonlinear granger causality method produces bidirectional causality where GDP and energy consumption affect each other. He uses in a multi-country study using 1971- 2003 data. Both methods share the conclusion of rejecting the neutrality hypothesis because efficiency in energy demand will reduce economic growth.

The Government of Indonesia issued Government Regulation of the Republic of Indonesia Number 70 of 2009 (PP No.70 /2009) concerning Energy Conservation. Based on that regulation in article 12 (2) states that users of energy sources and energy users who use energy sources and or an energy greater or equal to 6,000 equivalent tons of oil per year are required to carry out energy conservation through management energy. Explanation related to setting the limit of 6,000 is base on the consideration that energy users with consumption greater than or equal to 6,000 equivalent tons of oil per year are not too many. However, the total energy consumption reaches around 60% (sixty percent) from national energy use. When connected with electricity consumption, it is equal to 69,780 MWh (1 toe = 11.63 MWh). Article 12 (3) states that energy management is carried out by appointing energy managers, compiling energy conservation programs, carrying out energy audits regularly, carrying out energy audit results recommendations, and reporting energy conservation implementation annually to the Minister, governor, or regent/mayor following their respective authority. Article 5 and Article 6 describe the responsibilities of regionalgovernments at the provincial and district/city levels, including formulating and determining energy conservation policies, strategies and

programs; developing quality human resources in the field of energy conservation; conduct comprehensive and comprehensive outreach to the use of technology that applies energy conservation; allocating funds in the context of implementing energy conservation programs; provide facilities and/or incentives in the framework of implementing energy conservation programs; conduct technical guidance on energy conservation for entrepreneurs, users of energy sources, and energy users; implementing energy conservation programs and activities; and provide guidance and supervision of the implementation of energy conservation programs.

2. METHODS

Causality test is a study that aims to detect the presence or absence of a causal relationship between the variables studied. This test basically can indicate whether a variable has a two-way relationship, one-way, or no relationship at all. In the Granger causality test, it seems that the influence of the past on the present condition, so thedata used is time-series data. Testing the direction of Granger causality of the two variables X and Y can be done using an autoregressive vector (VAR) model on the condition that the data must be stationary. The concept of Granger causality express in the following equation where α is a constant; β, λ, γ, and δ are estimated parameters; υ and ε are serially uncorrected error terms; and m and n represent the number of lags (Chontanawat, 2006).

$$\ln Y_t = \alpha_1 + \sum_{i=1}^{m} \beta_i \ln Y_{t-i} + \sum_{j=1}^{n} \lambda_j \ln X_{t-j} + \upsilon_t \quad (1)$$

$$\ln X_t = \alpha_2 + \sum_{i=1}^{m} \gamma_i \ln X_{t-i} + \sum_{j=1}^{n} \delta_j \ln Y_{t-j} + \varepsilon_t \quad (2)$$

Causality testing in this study was carried out using the results of modifying the Granger causality test standard by Toda and Yamamoto (Statistical inference in vector autoregressions with possibly integrated processes, 1995) in Suryanto (Suryanto, 2013). It can use for variables that are not stationary but using data levels and use for variables that have order integration.

The first step is determining the maximum order of integration through the unit root test using the augmented Dickey-Fuller (ADF), Phillips-Perron (PP), or Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. The test is carried out to find out whether the time series data used has a root unit problem or the data is not stationary at the zero level (level), first degree (first difference), and second degree (second difference).

The second stage is the variables that have the same integration order, tested cointegration with the Engle and Granger (Co-Integration and Error Correction: Representation, Estimation, and Testing, 1987) approach and the Johansen and Juselius approach. Cointegration testing with the Johansen approach can indicate a relationship between variables is long-term (long-run relationship) or not.

The third stage is the preparation of estimation models. If the variables tested do not have cointegration, the estimation does with the VAR (p) model. However, if the variables tested have cointegration, the estimation does with a vector error correction model (VECM) where EC is the error correction term, and σ is an estimatedparameter (Chontanawat, 2006).

$$\ln Y_t = \alpha_1 + \sigma_1 EC_{t-1} + \sum_{i=1}^{m} \beta_i \ln Y_{t-i} + \sum_{j=1}^{n} \lambda_j \ln X_{t-j} + \upsilon_t \quad (3)$$

$$\ln Y_t = \alpha_1 + \sigma_1 EC_{t-1} + \sum_{i=1}^{m} \beta_i \ln Y_{t-i} + \sum_{j=1}^{n} \lambda_j \ln X_{t-j} + \upsilon_t \quad (4)$$

The model that will use in estimation requires testing so that it is not miss-specified (there is no serial correlation). According to Widarjono (2009), determining the exact number of lag lengths can eliminate the nature of serial correlation in the model. Criteria used to determine the optimum lag length include Sequential Modified LR Test Statistics (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), and Hannan-Quinn Criterion (HQ). After adding the maximum order integration (m lags) in the selected model, a Granger causality test performed.

3. RESULT AND DISCUSSION

The variables that will be part of this study are GRDP and electricity consumption. Historical data related to the regional economy was obtained from the Central Statistics Agency of South Kalimantan Province while historical data related to electricity was obtained from the State Electricity Company (PT PLN). Data are the samples of historical data from 2000 to 2018 amounted to 19 data. In the case of social and economic data samples, the amount of

data more than two data can still be used in statistical analysis as long as it has passed the classical assumption test.

The variables used in this study are GRDPbased on 2010 cash prices as a representation of economic conditions (Yt) and electrical energy consumption as a representation of energy consumption (Xt). Based on Suryanto (Suryanto, 2013), endogenous variables are converted into natural logarithms (lnXt and lnYt) to reduce the heteroscedasticity problem in the estimation model.

Stationary testing is carried out with ADF, PP, and KPSS tests to find out whether the time series data used has a unit root problem or the data is not stationary at zero, first difference and second difference. These methods chose in order to get robust results. ADF and PP tests are based on the null hypothesis if the p-value is more significant than 5%. The variable has a unit root (not stationery) with a lag length criteria using the Schwarz Info Criterion. In contrast, the KPSS test base on the null hypothesis if the statistical value ofthe test results is greater than Critical values at the 5% significance level are stationary variables.

Based on Table 1, the GRDP variable in stationarity testing using the ADF and PP methods, the null hypothesis rejects, which means that the alternative hypothesis accepts the second difference. Whereas in testing using the KPSS method, the null hypothesis is accepted. So it canbe concluded that the data on GRDP variables are stationary, and co-integrity testing can be done.

TABLE 1. Unit Root Test Results In Grdp Variable

Tests	ADF	PP	KPSS	
None				
Level	0.9870	0.9990		
1st diff	0.6696	0.7918		
2nd diff	0.0003*	0.0003*		
Intercep				
t Level	0.9013	0.9781	0.463	(0.587818)*
1st diff	0.2468	0.2956	0.463	(0.170056)
2nd diff	0.0066*	0.0054*		
Trend and Intercept				
Level	0.2291	0.4937	0.146	(0.101874)
1st diff	0.5863	0.7225	0.146	(0.150613)*
2nd diff	0.0143*	0.0013*		

Notes: (...) is the value of the statistical test results in the KPSS method. * means a null hypothesis is rejected in ADF and PP methods. ** means the null hypothesis is accepted in the KPSS method.

Based on Table 2, The variable electrical energy consumption in stationarity testing is using the ADF and PP methods; the null hypothesis is rejected, which means that the alternative hypothesis accepts at the first difference. Whereas in testing using the KPSS method, the null hypothesis is accepted. So it can be concluded that the data on electrical energy consumption variables are stationary and co-integrity testing used.

TABLE 2. Unit Root Test Results In Electricity Consumption Variable

Tests	ADF	PP	KPSS	
None				
Level	0.9881	0.9950		
1st diff	0.0006*	0.0005		
Intercep				
t Level	0.8084	0.8084	0.463	(0.558083)*
1st diff	0.0008*	0.0008*	0.463	(0.119124)
Trend and Intercept				
Level	0.3756	0.3881	0.146	(0.093981)
1st diff	0.0299*	0.0050*	0.146	(0.118052)*

Notes: (...) is the value of the statistical test results in the KPSS method. * means a null hypothesis is rejected in ADF and PP methods. ** means the null hypothesis is accepted in the KPSS method.

Cointegration testing is carried out in two approaches, namely the Engle-Granger approach for testing each variable and the Johansen approach for testing variables together. Cointegration testing with the Johansen approach can indicate a relationship between variables is long-term (long-run relationship) or not. The null hypothesis used in cointegration testing is that if the p-value is higher than the significance level (5%), then there are no integrating variables.

TABLE 3. Cointegration Test Results Engle-Granger Approach

Dependent	t-statistic	Prob.*	z-statistic	Prob.*
$Ln(X_t)$	-2.751907	0.2265	-12.14029	0.1378
$Ln(Y_t)$	-2.672635	0.2526	-12.04098	0.142

Note: *MacKinnon (1996) p-values

The Engle-Granger cointegration test results shown in Table 3. It shows the p-values of statistics and z- statistics do not reject the null hypothesis, so the variables Ln (Xt) with p-values 0.2265 and 0.1378 and the variable Ln (Yt) with p-values 0.2526 and 0.142, not cointegrated at the 5% significance level.

TABLE 4. Cointegration Test Results Engle-Granger Approach

Rank Test	Prob.**
Trace Statistic	0.2
Max-Eigen Statistic	0.762

Note: **MacKinnon-Haug-Michelis (1999) p-values

The cointegration test results with the Johansen approach shown in Table 4 show that the p-value for both the maximum eigenvalue and trace statistics is higher than the 5% significance level. The null hypothesis is accepted, which means cointegration cannot find, and there is no long-term relationship between the variable energy consumption and GRDP of South Kalimantan Province. Based on the results of cointegration testing, a standard Granger causality test can be performed to test the causality relationship.

Granger causality testing performed on variables that arranged in the form of an autoregressive vector model (VAR). Criteria used to determine lag length include Akaike Information Criterion (AIC), Schwarz information Criterion (SC), and Hannan-Quinn information criterion (HQ). Based on Table 5, the lag length, based on the indication of these criteria, choose lag 1 (one).

TABLE 5. Lag Length Criteria

Lag	AIC	SC	HQ
0	-1.51898	-1.422406	-1.514035
1	-9.067482*	-8.777761*	-9.052646*
2	-8.785252	-8.302385	-8.760526
3	-8.503218	-7.827203	-8.4686

*Notes: *indicates lag order selected by the* criterion

The serial correlation test with LM-test performed on the VAR (1) model with a null hypothesis that if the p- value was greater than the significance level (5%), then the VAR (1) modeldid not experience autocorrelation. Based on the test results (p-value = 0.5297), prove VAR model (1) is free from serial correlation problems. Model VAR (1) is also said to be the goodness of fit because it has a coefficient of determination (R2) of0.950298 (lnXt) and 0.999637 (lnYt). The estimation modeling results are as follows:

$$\ln X_t = 0{,}235483(\ln X_{t-1}) + 1{,}077749(\ln Y_{t-1}) - 8{,}767832 \quad (5)$$
$$R^2 = 0{,}950298 \qquad SE = 0{,}096398$$

$$\ln Y_t = -0{,}066589(\ln X_{t-1}) + 1{,}100375(\ln Y_{t-1}) - 0{,}836877 \quad (6)$$
$$R^2 = 0{,}999637 \qquad SE = 0{,}005690$$

Granger causality test is performed to determine the direction of the relationship between the variable energy consumption (lnXt) and GRDP (lnYt) with a null hypothesis. If the p-value is more than the 5% significance level, the GRDP does not affect the electricity consumption and electricity consumption does not affect the GRDP.

TABLE 6. Granger Causality Test Results

Null Hypothesis	F-Statistic	Prob.	
$\ln Y_t$ does not Granger Cause $\ln X_t$	8.01853	0.0126	rejected
$\ln X_t$ does not Granger Cause $\ln Y_t$	19.0882	0.0006	rejected

Based on Table 6, both GRDP on electricity consumption and electricity consumption on GRDP have p- values less than 5% (0.0126 and 0.0006), so the null hypothesis is rejected. The result shows that a short-run causal relationship occurs in two directions; the GRDP affects the consumption of electrical energy, and the consumption of electrical energy affects the GRDP.

4. CONCLUSIONS

In pursuance of Suryanto (Suryanto, 2013), there are two opinion groups regarding the relationship between energy and economic growth. The first group believes that energy is only an intermediate input in the production process. It believes that even though energy resources are limited, the economy can still grow due to the influence of technological developments and the use of other factors of production more efficiently, including the use of renewable energy. In other words, this group supports the neutrality hypothesis or conservation hypothesis. This hypothesis implies that the limitations or obstacles to energy supply will not harm economic growth. The government can simultaneously adopt energy conservation and economic growth policies, and the second group believes that energy consumption is a factor that limits economic growth. Technological developments and other production inputs cannot replace the critical role of energy in the production process. Furthermore, energy is a significant factor in the production process because other factors such as labor and capital cannot work without energy. This group supports the growth hypothesis, which means that disruptions or obstacles to energy supply can harm economic growth.

So far, research related to the causality of economic growth and limited energy consumption has been carried out in the scope of multi-country studies and single-country studies. However, studies in the regional scope, especially in South Kalimantan Province, have never been done. It is

because attention to energy conservation policies is still in the form of top-down management. In contrast, the implementation of conservation policies will have different impacts on each province because the direction of causality in each province also has different possibilities.

Based on the results of the Granger causality test for South Kalimantan Province in the short term, there is bidirectional causality from GRDP to electricity consumption and electricity consumption to GRDP. It explains that the GRDP is one of the variables that influence the amount of electricity consumption in South Kalimantan Province. So when economic growth occurs, it will have an impact on increasing electricity consumption. Besides, electricity consumption itself is also one of the variables that influence the GDP fluctuation. When the amount of electricity consumption disrupted, it can negatively affect economic growth in the province of South Kalimantan. In the short term, this is in line with the growth hypothesis,which states that disruptions or obstacles to energy supply can impact economic growth. The use of electrical energy in South Kalimantan Province for economic activities already has a high proportion. Based on statistics from PLN in 2018, electricity sales for the industrial and business sectors reached 31% of the total electricity sales in South Kalimantan Province. The efficient use of electricity or the reduction of electricity consumption through demand-side management can have an impact on economic sectors, namely business and industry, where these sectors are directly related to the formation of GRDP in South Kalimantan Province.

Based on the results of the cointegration test using the Johansen approach, there is no long-term relationship between the GRDP variable and the consumption of electrical energy. If we looked at the condition of the South Kalimantan Province in 2015 when there was a decrease in the level of electricity consumption at -20.39%, however, the economy could still grow positively at 3.82%. Likewise, if at conditions in 2018 where the levelof electricity consumption fell by -8.09%, the economy could still grow positively at 5.13%.

According to Suryanto (Suryanto, 2013), based on the neutrality hypothesis or conservation hypothesis, even though energy resources are limited, the economy can still grow due to the influence of technological development and the use of other production factors more efficiently, including the use of renewable energy. This hypothesis implies that the limitations or obstacles to energy supply will not harm economic growth sothat the government can simultaneously adopt energy conservation and economic growth policies.

The application of the responsibility to the Provincial Government of South Kalimantan under PP No.70/2009 regarding Energy Conservation is applying demand-side management for electrical energy efficiency. In the short term, it will have an impact on economic sectors related to the formation of GRDP, but in the long run, the effect will not be significant.

The limitation of this study is that the multiplier effect of implementing energy conservation policies cannot be measured. Analysis of the multiplier effect using the Input-Output Table (IO) of South Kalimantan Province cannot do because the IO table update is done every ten years so that theavailable OI table was in 2010. The period is too far (nine years), allowing changes in the structure of technical coefficients so that the multiplier effects analysis cannot represent the present conditions.

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