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The Dynamic Link of Energy Consumption, Economic Growth and Poverty in Eastern Indonesia: Panel VECM and FMOLS Approach

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ABSTRACT

This study aims to investigate the pattern of dynamic relationships between energy consumption (EC), economic growth (EG), and poverty in panel data set of 12 provinces of Eastern Indonesia during the period 2009–2019. Panel vector error correction model and fully modified ordinary least squares were applied to analyze the dynamic link of the variables both in the short and long term. All secondary data used were collected from BPS and the Ministry of Energy and Mineral Resources. The results of this empirical study in the short term corroborate the neutrality hypothesis which reveals that there is no short-term relationship in the case of energy-growth nexus, energy-poverty nexus, and poverty-growth nexus. In the long term, empirical evidence corroborates the feedback hypothesis in the case of the energy-growth nexus and poverty-growth nexus. Concerning the long-run energy-growth nexus, the increase in EC has a positive effect on the acceleration of EG, and also the increase in EG requires the fulfillment of adequate EC. Furthermore, a feedback relationship is found in the poverty-growth nexus case which explains that the progress of poverty reduction is significantly determined by sustainable EG that supports several previous studies and the trickle-down economics argument or pro-growth-poverty. On the other hand, widespread poverty has a negative impact on the achievement of EG.

Keywords: Energy, Economic Growth, Poverty, Causality, Panel Vector Error Correction Model, Fully Modified Ordinary Least Squares
JEL Classifications: O11; I3; Q4

1. INTRODUCTION

In the last few decades, poverty is still one of the crucial problems that are difficult to solve in Indonesia, especially in the provinces of eastern Indonesia. Although there is a tendency for the poverty rate to decline from year to year, the percentage of people living below the poverty line in eastern Indonesia is still relatively high compared to other provinces in western Indonesia. In 2019, the number of poor people in Indonesia was 24,786 thousand people or reached a percentage of poor people of 9.31% of the total population. According to data from the Indonesian Central Statistics Agency (BPS), the distribution of poverty is uneven, with the majority of poor people still concentrated in rural areas, and several provinces in Eastern Indonesia, such as Papua, West Papua, Maluku, and East Nusa Tenggara. These provinces have the highest poverty rates among other provinces with poverty rates of 27.04%, 21.84%, 17.7%, and 20.9%, respectively.

One of the main factors that can play an important role in increasing the level of life of the population is the availability of adequate energy consumption (EC) that can be accessed by all levels of society, especially poor households. In fact, EC is not evenly distributed throughout Indonesia with the average indicator of achieving electricity consumption in eastern Indonesia in 2019 of 415.23 kWh/year, lower than the average total national electricity consumption/total province. Another issue is also related to the usage of energy per capita has not reached the target and is still far behind several neighboring countries such as Vietnam and

Malaysia. Based on data from the Ministry of Energy and Mineral Resources, the achievement of electricity consumption in 2019 is only 1084 kWh/capita, while the target is 1200 kWh/capita. Meanwhile, one of the important elements to create and accelerate sustainable economic growth (EG) is the availability of adequate electricity energy. In 2019, the eastern Indonesian economy was able to grow by 4% or experienced an average growth during 2009-2019 of 6.5% per year.

In the perspective of the causal relationship between EC, poverty, and EG has been widely examined in many countries, but the findings are mixed, with different results in different countries depending on the econometric methods used and the research time spans. In the review of Payne, (2010) relating to energy-growth nexus, 31.15% of the country studies support the neutrality hypothesis which states that there is no relationship whatsoever in the case of energy-growth nexus. However, these empirical findings are challenged by the other three hypotheses, namely energy-led growth (22.95%), conservation (27.87%), and feedback hypothesis (18.03%).

Inconsistent empirical results that produce unclear consensus emerge in several recent studies which reveal that EC and EG have a two-way causal relationship (Kasperowicz, 2014); (Wolde-Rufael, 2014); (Gurgul and Lach, 2012); (Hamdi, et al., 2014); (Tang and Tan, 2013); (Cowan, et al, 2014). Other studies have failed to find the feedback causality because some authors have also demonstrated that there is evidence of the existence of a unidirectional relationship from EC to EG, which strengthens the energy-based growth hypothesis (Inani and Tripathi, 2017); (Tang, et al., 2016); (Wolde-Rufael, 2014); (Iyke, 2015); (Karanfil and Li, 2015). However, other studies such as Salahuddin and Alam (2015), Adom (2011), Shaari et al. (2013) also concluded different findings with both the feedback hypothesis and the energy-led growth hypothesis. Their findings support the conservation hypothesis that states that rapid EG encourages increased use of EC.

In the case of poverty-growth nexus, several studies have found that EG has a significant impact on poverty reduction or that there is a unidirectional causality running from EG to poverty reduction (Nguyen, et al., 2020); (Odhiambo, 2009); (Ginting and Dewi, 2013). Meanwhile, Nyasha, et al. (2017) and Nuruddeen and Ibrahim (2014) found a one-way causality that runs from poverty reduction to EG. Other studies have found that EG and poverty have a long-run bi-directional causality (Garza-Rodriguez, 2018); Afzal et al., 2012); (Dewi, et al., 2018) whereas Okoroafor et al. (2013); Odhiambo and Nindi (2015); Omoniyi (2018) have argued that there is no strong relationship between EG and poverty.

Several phenomena or research gaps described are interesting for further research, especially regarding the pattern of relationships between the three variables. The objective of this study is to examine and analyze the dynamic relationship between electricity consumption, poverty, and EG in the short and long run for panel data of 12 provinces of Eastern Indonesia from 2009 to 2019.

The rest of the article is arranged as follows: The second section summarizes and briefly explains the review of relevant literature. The third section describes in detail the most important methods used. Explaining several research methods, which includes an explanation of the data and variables used, specifications of the econometric model, testing data, panel vector error correction model (VECM), and fully modified ordinary least squares (FM-OLS) analysis. The fourth section describes the findings and discussion. The fifth section is the final section, which includes conclusions and recommendations.

2. LITERATURE REVIEW

In Solow's neo-classical model, output per worker/GDP per capita is not a measure of the main level of welfare, but in conditions of the golden rule, the highest level of welfare can be achieved at the maximum level of consumption because at this level maximum satisfaction is achieved (Mankiw, 2011). An increase in EC is one indicator of an increase in the level of population welfare which could be related to poverty reduction and EG or vice versa, there could be a causal relationship between the three variables. however, in the long-run output is not determined by consumption but consumption determines the short-run output growth as explained by the Keynes model (Romer, 2011).

Since the early findings in empirical research, the Kraf and Kraf study (1978) about the existence of an energy growth nexus has drawn more attention to more comprehensive research with precise econometric analyses among economists, researchers, and decision-makers. Amaluddin (2020) researched in 33 Indonesian provinces to examine the short and long-term relationship between the variables of electricity consumption, internet access, and EG. The data used are panel data for the years 2009-2018 by applying two analytical methods both Panel VECM (PVECM) Granger Causality Test and DOLS. The results of this study concluded that electricity consumption and EG have a positive relationship that affects each other both in the short and long term as well as supports the feedback hypothesis.

Inani and Tripathi (2017) conducted a study in India to examine the short and long-term relationships between Information and Communication Technology, electricity consumption, and EG variables. The data used are time-series data from 1991 to 2014, by applying the autoregressive distributed lag (ARDL) and the VECM Granger Causality test method. Their research results reveal that electricity consumption has a positive and significant effect on EG, both in the short and long term. However, there was no effect of EG on electricity consumption in the short and long term.

Iyke (2015) researched in Nigeria using time series data for 1971-2011, aiming to highlight the dynamic relationship between electricity consumption and EG, using VECM analysis. The results of this study reveal that there are different flows of the relationship between electricity consumption and EG in both the short and long term. This study supports the energy-led growth hypothesis which states that electricity consumption has a positive relationship and has a significant effect on EG.

Wolde-Rufael (2014) conducted a study in several European countries (transition economies) and found different results. This study used a Granger Causality panel bootstrap approach during the years 1975-2010. For the cases of Belarus and Bulgaria, they found a relationship that supports the energy-led growth hypothesis which states that electricity consumption has a positive and significant relationship to EG. Empirical results that support the conservation hypothesis (growth-led energy) which states that EG encourages the use of electric energy is found in the case of the Czech Republic, Latvia, Lithuania, and the Russian Federation, while the relationship that supports bi-directional causality (feedback hypothesis) is only found in Ukraine. The rest, namely Albania, Macedonia, Moldova, Poland, Romania, Serbia, Slovak Republic, and Slovenia, supported the neutrality hypothesis or did not find any relationship.

Shaari, et al. (2013) employed the Granger causality model and Johansen co-integration to highlight the linkages between EC and economic performance in Malaysia. Using data from 1980 to 2010, this study supported the conservation hypothesis that revealed the existence of causality runs from EG to electricity consumption, but oil and coal consumption do not Granger cause EG and vice versa.

Kasperowicz (2014) applied the Granger causality model to investigate the relationship between EC and EG in Poland by using time series data from 1996 to 2012. This study revealed that there was a bi-directional causality that supported the feedback hypothesis. The evaluated model proved that EC is a pro-growth variable in Poland. The bi-directional causal link also existed between capital and EG.

Cowan, et al. (2014) conducted a study in BRICS countries and found different results. This study used a panel causality analysis over the period 1990-2010. For the cases of Russia, they found a relationship that supported the feedback hypothesis which stated that electricity consumption and EG affect each other. Empirical results that support the conservation hypothesis (growth-led energy) which states that EG encourages the use of electric energy is found in the case of South Africa, while the relationship that corroborates the neutrality hypothesis exists for Brazil, India, and China.

Overall studies across countries regarding the energy-growth nexus conclude mixed findings. An interesting debate with inconsistent results and not yet clear consensus is also found on the poverty-growth nexus case. Proponents of trickle-down economics argue that increasing income through high EG will create more jobs, more output, more income, and less poverty because higher growth and income at its peak will trickle down to the bottom and reach the poor. As long as the economy grows, the benefits will ultimately have a positive impact on the poor and make it through a system that will make everyone better off. When growth occurs, the impact of that growth will eventually flow to the poorest people (Todaro and Smith, 2011).

Several previous studies as well as current work highlight and examine the trickle-down economics argument or pro-growth-poverty nexus. They believed that strong EG is one of the best instruments for improving employment opportunities and quality of life. The study of Nguyen, et al. (2020) found a robust negative relationship between the initial poverty rate and subsequent EG. In line with the study of Nguyen, et al. (2020), Odhiambo (2009) employed a trivariate causality model. Using the cointegration and error-correction model, this study aims to investigate the dynamic relationship between financial development, EG, and poverty in South Africa. The empirical results of this study indicate that Granger's EG causes poverty reduction that corroborates the pro-growth hypothesis. Studies on dynamic relationships like Nyasha, et al. (2017) in Ethiopia using ARDL bounds testing approach, cointegration, and the ECM-based Granger-causality test show that in the short term, there is a bi-directional causality relationship between EG and poverty reduction. However, in the long run, there is a uni-directional causality running from EG to poverty reduction.

This study has five hypotheses as follows:
- H1: There is a short-run causal link between EC, poverty reduction, and EG
- H2: There is a long-run causal link between EC, poverty reduction, and EG
- H3: EC has a long-term significant effect and positively affects EG, and vice versa
- H4: EG has a long-term significant effect and negatively affects poverty, and vice versa
- H5: EC has a long-term significant effect and negatively affects poverty and vice versa.

3. DATA AND METHODOLOGY

3.1. Data and Variable Measurement

This study employs a combination of both the cross-sectional and time-series data, known as Panel data that incorporates a panel data set of 12 provinces in eastern Indonesia during the period 2009–2019. The empirical analysis on the relationship between EC, poverty, and EG in this study consists of 3 (three) variables, namely: (1) EG variable, measured by the natural logarithm of Gross Regional Domestic Product per capita (IDR million). (2) The natural logarithm of electricity consumption per capita (Kwh) is used as a proxy of the EC variable. (3) Poverty variable (POV) is measured by the percentage of the number of poor people (POV).

This study employs secondary data, taken from the Central Bureau of Statistics of Indonesia (BPS) and Indonesia's Ministry of Natural Resources and Mineral.

3.2. Panel Unit Root Test

One of the primary benefits of using panel unit root tests in panel data is that it provides more observations to increase variability and data information, allowing for more efficient estimates to be produced. The root panel unit test is used to examine the level of integration between the study variables and the stationary properties of all the used variables.

To explore the degree of integration between variables, the study used different tests of panel unit root, including Levin, Lin and Chu (LLC), Augmented Dickey-Fuller (ADF)-Fisher and Philips-Perron (PP)-Fisher testing (Amaluddin, 2020). Panel unit root tests that rely on cross-sectional independence use these approaches as the most relevant references. LLC (2002) developed a panel-based proposition based on the ADF test that examines the presence of homogeneity in the dynamics of the autoregressive coefficients. The panel data unit root test of LLC (2002) in Baltagi (2005) using the following ADF specifications:

$$\mathrm{DY}_{\mathrm{it}} = \alpha \mathrm{Y}_{\mathrm{it\text{-}1}} + \sum_{j=1}^{p} \beta \mathrm{DY}_{\mathrm{it\text{-}j}} + \mathrm{X}_{\mathrm{it}}\delta + \varepsilon_{\mathrm{it}} \quad (1)$$

Where Y_{it} = panel data. DY_{it} = difference form of Y_{it}., α = p-1, p_i = number of lags adjusted for first difference. ε_{it} = error term.

Im, Pesar, and Shin (IPS) developed a panel data unit root test that combines the dimensions of time series data with cross-sectional dimensions. It has the powerful property of investigating panel unit roots and is very useful for economists to analyze long-term relationships in panel data. In its development, IPS needs to be combined with other unit root tests to get accurate and precise results.

3.3. Panel Cointegration Test

The cointegration test is used to determine the presence of the long-term relationship between variables using stationary data. All of the variables used (EC, poverty, and EG) must be in the same order or integrated at the same level to fulfill the requirement of PVECM (Amaluddin, 2020).

To explore the presence of co-integration between variables, the study used different tests of panel cointegration, including the Pedroni and Kao Test. Kao (1999) considers a homogenous cointegrating vector, whereas Pedroni (2004) allows for some heterogeneity. However, both rely on the cross-sectional independence of the panel unit to derive asymptotic normality for their test statistics.

Pedroni in Neal (2014) allows for some heterogeneity in the cointegration relationship. He proposes seven powerful statistics tests namely Panel parametric ADF-statistic, Panel non-parametric PP-Statistic, Panel rho, and Panel v-Statistic are four within-dimension statistics, while group ADF-Statistic, group PP-Statistic, and group rho-Statistic panel are three between-dimension statistics.

$$Y_{it} = \alpha_i + \delta_{it} + \beta_{1i} x_{1it} + ... + \beta_{Mi} x_{Mit} + e_{it} \quad (2)$$

$$\Delta Y_{it} = \Delta \beta_{1i} x_{1it} + ... + \beta_{Mi} x_{Mit} + e_{it} + \eta_{it} \quad (3)$$

$$\hat{e}_{it} = \hat{\gamma}_{1i} \hat{e}_{it-1} + \hat{u}_{it} \quad (4)$$

$$\hat{e}_{it} = \hat{\gamma}_{1i} \hat{e}_{it-1} + \sum_{k=1}^{k} \gamma_{ik} \Delta \hat{e}_{it-k} + u_{it} \quad (5)$$

Under the null hypothesis of no cointegration, Kao (1999) in Baltagi (2005) suggested new powerful cointegration tests. The ADF panel cointegration test is assumed to be homogeneous. One of the two tests is based on the DickeyFuller type test (DF), and the other on the ADF. The panel regression specification of estimated residual (e_{it}):

$$y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it} \quad (6)$$

The Kao test is based on a residual ADF version (ε_{it}) of the auxiliary regression $\varepsilon_{it} = \rho\varepsilon_{it}-1 + \nu_{it}$, or on the modified version of the pooled specification can be written as:

$$\varepsilon_{\mathrm{it}} = \rho\varepsilon_{\mathrm{it\text{-}1}} + \sum_{J=1}^{P} \lambda_J \Delta\varepsilon_{it-j} + v_{it} \quad (7)$$

In the previous equation, the ADF test statistic is the standard t-statistic. The null hypothesis of no cointegration at the ADF test statistics is written as follows:

$$ADF = \frac{t_{ADF} + (\frac{\sqrt{6N\hat{\sigma}v}}{2\hat{\sigma}0v}}{\sqrt{(\frac{\hat{\sigma}_{0v}^2}{2\hat{\sigma}_v^2} + (10\hat{\sigma}_{0v}^2)}} \quad (8)$$

Where $\hat{\sigma}_v^2 = \Sigma_{\mu\varepsilon} - \Sigma_{\mu\varepsilon} \Sigma_\varepsilon^1 \hat{\sigma}_{0v}^2 = \Omega_{\mu\varepsilon} - \Omega_{\mu\varepsilon}\Omega_\varepsilon^1\Omega$ is the long-run covariance matrix, and tADF is the t-statistic of the ADF. The t-statistic of the Kao panel data cointegration test (ADF) compared with the Probability value of t-statistic. When the statistical value exceeds the critical value or the probability value is <0.05, the null hypothesis is rejected indicating the presence of cointegration.

3.4. PVECM

Based on the purpose of this study, the PVECM is used to investigate the short dan the long-run relationship between three variables (EGR, POV, EC). In the PVECM method, there are several pre-estimation tests before the main estimation. PVECM is one of the quantitative methods widely used in previous studies (Amaluddin, 2020).

The VECM method was first popularized by Engle and Granger to correct the short-term disequilibrium against the long-term relationship. The main requirement in PVECM that distinguishes it from PVAR or ARDL is that in PVECM it must be integrated in the same degree or order also consider the presence of cointegration which has implications for short-term disequilibrium correction, allowing for equilibrium or long-term relationships. The determination of the cointegrated vector (cointegrated vector) shows the existence of long-term behavior and allows to capture of causality relationships (Rachev et al., 2007; Gujarati and Porter, 2009, Ekananda, 2019).

PVECM treats the three variables used (EGR, POV, and EC) as endogenous variables involving the lag value of each variable and ECT on the right-hand side of the equation. The specification of the Panel VECM model can be written as follows:

$$\Delta EC_{it} = \alpha_1 + \sum_{i=1}^{p} \beta_{11} EC_{it-1} + \sum_{i=1}^{q} \beta_{12} \Delta EGR_{it-1} + \sum_{i=1}^{r} \beta_{13} POV_{it-1} + \lambda_1 ECT_{it-1} + \mu_{1_{it}} \quad (9a)$$

$$\Delta EGR_{it} = \alpha_2 + \sum_{i=1}^{p} \beta_{21} EGR_{it-1} + \sum_{i=1}^{q} \beta_{22} \Delta EC_{it-1} + \sum_{i=1}^{r} \beta_{23} POV_{it-1} + \lambda_2 ECT_{it-1} + \mu_{2_{it}} \quad (9b)$$

$$\Delta POV_{it} = \alpha_3 + \sum_{i=1}^{p} \beta_{31} \Delta POV_{it-1} + \sum_{i=1}^{q} \beta_{32} \Delta EC_{it-1} + \sum_{i=1}^{r} \beta_{33} EGR_{it-1} + \lambda_3 ECT_{it-1} + \mu_{3_{it}} \quad (9c)$$

Where EC is the EC variable, Pov is the POV, is the EG variable, ECT_{it-1} is the lagged error correction term derived from the long-run cointegrating relationship of equation (1), t is time (the year 2009-2019) and i is cross-section data (12 provinces of eastern Indonesia). The ECT coefficients also show the speed of adjustment and contain information about the long-term relationship (Gujarati and Porter, 2009, Ekananda, 2019).

The coefficient of ECT (λ1, λ2, λ3) are expected to $-1 < ECT \leq 0$ or expected to $0 \leq ECT < 1$ (Asteriou and Hall, 2011). ECT in equation (9a) is expressed as $ECT_{it} = EC_{it} - \beta_0 - \beta_{12}EGR_{it} - \beta_{13}POV_{it}$.

3.5. Vector Error Correction (VEC) Granger Causality/Wald Test

One of the advantages of Wald/VEC Granger causality is that it combines several lag variables into a summary of information regarding the existence of a short-term causal relationship. One of the advantages of Wald/VEC Granger causality is that it combines several lag variables into a summary of information regarding the existence of a short-term causal relationship. The VEC Granger causality test/Wald test estimates a test statistic based on the unrestricted regression and the results of the dynamic short-run relationship can be in various directions/channels such as one-way causality link (uni-directional causality), two-way/feedback causality, and neutral linkage or no causality relationship. The standard VEC Granger/Causality Test/Wald test has statistics based on an asymptotic Chi-square (χ^2) distribution.

3.6. FM-OLS

FM-OLS regression was proposed by Phillips and Hansen (1990) in Kao and Chiang (2000) to provide optimal estimates of cointegrating regressions. This estimator employed a semi-parametric correction to eliminate the problems caused by the long-run correlation between the cointegrating equation and stochastic regressors innovations by accounting for serial correlation effects and for the endogeneity in the regressors that results from the existence of a cointegrating relationship. Thus, the OLS estimation technique has the power to produce a valid estimation for the long-run coefficient. The use of FMOLS improves the accuracy of the cointegration panel test and the previous PVECM estimation can allow the estimation results obtained in this study to be more accurate and precise.

4. RESULTS AND DISCUSSION

4.1. Data Description

Table 1 shows a data description containing several important indicators from 132-panel data observations. all variables were converted to natural logarithms except for the POV. The variables of EC, EG region (EGR), and poverty have average values (mean) of 5.632199, 10.03283, and 17.02004, respectively.

Table 1 also provides information that except POV, the statistic value of J-B test has a probability value >0.05 or is not statistically significant, indicating that the data is normally distributed. This condition indicates that there is a lower gap in economic development, EC, and poverty alleviation among the eastern provinces of Indonesia. Another indicator that reflects data that is normally distributed is the kurtosis value <3, which indicates that the data distribution curve is platykurtic.

Table 2 describes the Pearson correlation as one of the correlation matrix measures used to measure the strength and direction of a linear relationship between two variables. The correlation matrix is positive as indicated by the correlation between the POV and EGR variables and the correlation between the EC and EGR variables are 0.209 and 0.600, respectively, while the correlation between the POV and EC variables is negative at 0.288.

4.2. The Result of Panel Unit Root Test and Panel Cointegration Test

In the application of the PVECM, the first stage usually begins with a panel unit root test so that stationary and non-stationary variables

Table 1: Description of data

Indicators	EC	EGR	POV
Mean	5.632199	10.03283	17.02004
Median	5.639304	9.965824	15.69500
Maximum	6.567319	11.07728	37.53000
Minimum	4.416911	9.112182	6.370000
Std. Dev.	0.465510	0.476292	7.401314
Skewness	-0.160780	0.347458	0.681221
Kurtosis	2.546875	2.439335	2.833166
Jarque-Bera	1.697977	4.384898	10.36244
Probability	0.427848	0.111643	0.005621
Sum	743.4503	1324.334	2246.645
Observations	132	132	132

Source: Data processed, EC: Energy consumption, EG: Economic growth, POV: Poverty variable

Table 2: Correlation matrix

Variable	EC	EGR	POV
EC	1.000	0.600	-0.288
EGR	0.600	1.000	0.209
POV	-0.288	0.209	1.000

Source: data processed, EC: Energy consumption, EG: Economic growth, POV: Poverty variable can be identified and ensure that the data to be estimated in the PVECM model has the same degree of integration. Several strong methods will be employed to fulfill the stated objectives, namely LLC, Im, Pesaran and Shin (IPS), ADF-Fisher, and Philip-Perron (PP). Some of these methods are used in order to obtain accurate results, precision, and strengthen the analysis results.

Table 3 presents the results of the panel unit root test using well-known methods, namely LLC, IPS, DF-Fisher, and PP-Fisher. The purpose of the panel unit root test is to check the existence of stationarity and the level of integration of the variables used. From Table 3, information is obtained that the two variables (EC, EGR) are not stationary at the level or fail to reject the null hypothesis (there is a unit root) while the POV is stationary at the level or rejects the null hypothesis. However, all tested variables (EC, EGR, POV) were stationary at the first difference, indicated by a significance level or probability value <0.01 (statistically significant at alpha = 1%). In the first difference, the three variables tested (EC, EGR, POV) have the same level of integration, I(1).

Once the data/variables have the same level of integration. The next stage is cointegration testing aims to ensure that the variables tested have a long-term relationship, using the Pedroni and Kao cointegration test as presented in Table 4. The optimal lag selection results in lag 2, which is based on the Akaike information criterion and Schwarz criterion indicators.

Table 4 shows that the three tested variables have cointegration or support the existence of a long-term relationship, which is indicated by the significance level of the 4 indicators of the Pedroni cointegration test, at an alpha of 1%. The existence of cointegration in the three tested variables is also consistently demonstrated by the Kao cointegration test, with a significant t-statistic at an alpha of 1% (probability value <0.01).

4.3. PVECM and Wald Test

The third stage is to estimate and analyze the dynamic relationship pattern of the variables of EC, EGR, and POV in the framework of the PVECM. PVECM can provide accurate and precise information related to short-term and long-term causal relationships.

PVECM estimates are presented in Table 5, which explains that the ECT (-1) coefficient has a negative sign as the expected estimation results mean that the PVECM model specifications applied are valid and meet the econometric rules. Statistically, the ECT (-1) coefficient of the three variables (EC, EGR, POV) is significant at alpha = 1%, 5%, and 10%, respectively, indicating that the three variables have a long-term causal relationship.

Table 5 also provides information regarding the speed of adjustment from short-run to long-run equilibrium. When the EC variable is treated as the dependent variable, the ECT (-1) coefficient is -0.086, it is interpreted that the speed of adjustment of the variables of EGR and poverty (POV) to achieve long-term equilibrium is 8.6%. When the variables of EGR and poverty (POV) are treated as dependent variables, the speed of adjustment to achieve long-term equilibrium is 1.5% and 32.10%, respectively, which will be further confirmed through the estimation of the Panel FM-OLS, so that accurate and precise results can be obtained. The estimation results from Table 5 can also provide information that all of the estimated lag variables cannot reject H_0, indicating that there is no short-term relationship and can be confirmed clearly through the Wald/Granger Causality test.

One of the advantages of Wald/VEC Granger causality is that it combines several lag variables into a summary of information regarding the existence of a short-term causal relationship as presented in Table 6.

Table 6 shows the short-term dynamic relationship typically using the Wald/VEC Granger Causality Test statistic. Through statistical tests of several lag variables in the Wald/VEC causality framework, it can provide a comprehensive summary of short-term relationship information. From the appearance of Table 6, it can be seen that all variables (EC, EGR, POV) have chi-square statistics which are not statistically significant at the significance level of 10%, 5%, and 1% or fail to reject the null hypothesis. Thus, this study cannot prove a short-term relationship between energy-growth nexus, poverty-growth nexus, and energy-poverty nexus.

4.4. Panel Long-run Coefficient

Table 7 shows a statistical summary of the long-term FM-OLS coefficients. The three variables (EC, EGR, POV) have the expected sign and are consistent with several previous studies and also do not contradict the results of the cointegration test and VECM estimation. The existence of a causal relationship with long-term feedback is indicated by the significant ECT and FM-OLS coefficients in the energy growth nexus and the poverty growth nexus. The variable of EG has a significant effect in the long term and has a positive effect on EC at a significance level of 1%. The correlation coefficient of energy growth correlation is 1.264 and 0.376, it is interpreted that an increase in the EG of 1% will encourage EC by 1.26%. On the other hand, an increase in EC by 1% will increase EG by 0.37%.

As expected, the long-term relationship of the poverty-growth nexus has a negative sign and yields regression coefficients of -5.966 and -0.016, it is interpreted that a 1 % increase in EG will lead to a decrease in the poverty rate by 5.97%. Furthermore,

Table 3: Panel unit root test

Panel unit root test types	Variables in level			Variables in first difference		
	EC	EGR	POV	EC	EGR	POV
LLC	–3.760 (0.003)*	–0.503 (0.000)*	–8.081 (0.000)*	130.168 (0.000)*	–3.628 (0.000)*	–8.403 (0.000)*
IPS	–0.462 (0.322)	0.466 (0.679)	–3.837 (0.000)*	–6.626 (0.000)*	–2.571 (0.005)*	–3.459 (0.000)*
ADF-Fisher	24.052 (0.459)	31.661 (0.136)	54.905 (0.000)*	91.488 (0.000)*	48.143 (0.002)*	52.740 (0.000)*
PP-Fisher	37.104 (0.043)**	58.514 (0.000)*	82.997 (0.000)*	130.168 (0.000)*	74.063 (0.000)*	50.639 (0.000)*

Source: Data processed, Note: Value in parentheses () is P-value. *,**,***=Significant at α=1%, 5%, 10%, EC: Energy consumption, EG: Economic growth, POV: Poverty variable

Table 4: Panel cointegration test

Pedroni cointegration test (EC as dependent variable)		
Indicator	**t-statistic**	**Probability**
Within-dimension		
Panel v-statistic	–2.446	0.993
Panel rho-statistic	0.275	0.608
Panel PP-statistic	–9.693	0.000
Panel ADF-statistic	–3.459	0.000
Between-dimension		
Group rho-statistic	1.800	0.964
Group PP-statistic	–9.148	0.000
Group ADF-statistic	–3.201	0.000
Kao residual cointegration test (ELC as dependent variable)		
Indicator	**t-statistic**	**Probability**
ADF	–4.815	0.000

Source: Data processed, ADF: Augmented Dickey-Fuller, PP: Philips-Perron

Table 5: Panel VECM estimation results

Independent Variables	Dependent variables		
	ΔEC	ΔEGR	ΔPOV
Long-run coefficient			
ECT (-1)	–0.086*	–0.015**	–0.321***
Short-Run coefficient			
ΔEC (-1)		0.007	0.142
ΔEC (-2)		–0.001	0.258
ΔEGR (-1)	0.995		–0.010
ΔEGR (-2)	–0.118		–1.171
ΔPOV (-1)	0.979	–0.004	
ΔPOV (-2)	–0.371	–0.001	

Source: Data processed. Note: *, **, ***=Significant at alpha 1%, 5%, 10%. EC: Energy consumption, EG: Economic growth, POV: Poverty variable

Table 6: Wald test/VEC granger causality test

Dependent Variable	Independent Variable	Chi-sq	Df	P-value
EC	EGR	1.022	2	0.600
	POV	2.413	2	0.299
EGR	EC	0.355	2	0.837
	POV	1.199	2	0.549
POV	EC	0.879	2	0.645
	EGR	0.879	2	0.907

Source: Data processed, EC: Energy consumption, EG: Economic growth, POV: Poverty variable

Table 7: Panel FM-OLS estimation

Dependent variable	Independent Variable	FMOLS		Expected sign
		Coeff	t-stat	
EC	EGR	1.264	7.475*	+
	POV	–0.020	–1.633	-
EGR	EC	0.376	8.541*	+
	POV	–0.016	–2.598**	-
POV	EC	–2.060	–2.040**	-
	EGR	–5.966	–2.876*	-

Source: Data processed. Note: *, **, ***=Significant at α=1%, 5%, 10%. EC: Energy consumption, EG: Economic growth, POV: Poverty variable, fully modified ordinary least squares

an increase in the poverty rate will reduce EG by 0.06%. However, the long-run dynamic link of poverty and the EC variable only yields a one-way relationship that runs from EC to the POV (uni-directional causality).

5. DISCUSSION

This study aims to investigate the pattern of dynamic relationships between EC, EG, and poverty in 12 provinces of Eastern Indonesia using PVECM and FM-OLS. The results of this empirical study in the short term corroborate the proponent of the neutrality hypothesis which reveals that there is no short-term relationship in the case of energy-growth nexus, energy-poverty nexus, and poverty-growth nexus. In terms of short-run relationships, all variables (EC, EGR, POV) have chi-square statistics which are not statistically significant at the significance level of 10%, 5%, and 1% or fail to reject the null-hypothesis of H1. The findings of this research were in accordance with the study of Acaravci and Ozturk (2010) and Cowan et al. (2014) also support the framework of the neo-classical theory that energy has no impact on output growth.

In the long term, empirical evidence is found that corroborates the feedback hypothesis in the case of the energy-growth nexus and poverty-growth nexus. Concerning the long-run energy-growth nexus, the increase in EC has a positive effect on the acceleration of EG, and also the increase in EG requires the fulfillment of adequate EC. Furthermore, a mutually influencing relationship is found in the poverty-growth nexus case which explains that the progress of poverty reduction is significantly determined by sustainable EG that supports the several previous studies as well as current work highlight and examines the trickle-down economics argument or pro-growth-poverty nexus. They believed that strong EG is one of the best instruments for improving employment opportunities and quality of life. On the other hand, widespread poverty has a negative impact on the achievement of EG. Strong EG allows the poor to be able to access various available economic opportunities, both through job opportunities, small and medium business opportunities that can increase income as a standard of living measure. The income they receive can be invested in improving children's education to a higher level as an investment in human resources which in turn can accelerate long-term EG.

6. CONCLUSIONS AND RECOMMENDATIONS

This study aims to investigate the pattern of dynamic relationships between EC, EG, and poverty in 12 provinces of Eastern Indonesia using PVECM and FM-OLS. The results of this empirical study in the short term corroborate the neutrality hypothesis which reveals that there is no short-term relationship in the case of energy-growth nexus, energy-poverty nexus, and poverty-growth nexus.

In the long term, empirical evidence is found that corroborates the feedback hypothesis in the case of the energy-growth nexus and poverty-growth nexus. In relation to the long-run energy-growth nexus, the increase in EC has a positive effect on the acceleration of EG, and also the increase in EG requires the fulfillment of adequate EC. Furthermore, a mutually influencing relationship is found in the poverty-growth nexus case which explains that the progress of poverty reduction is significantly determined by sustainable EG. On the other hand, widespread poverty has a negative impact on the achievement of EG.

This study recommends greater attention to the improvement and distribution of energy infrastructure, in all provinces of Indonesia, especially in eastern Indonesia. EG is still one of the best solutions and instruments for poverty alleviation, but it needs to be accompanied by serious attention and political will of local governments towards the poor, especially in border areas, isolated and underdeveloped areas.

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