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Energy Poverty Impact on the Economics of Indonesia Using ARDL Approach

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Abstract: Energy poverty is a global threat to human development path. This study is about the cointegration relationship between energy poverty and the economy of Indonesia for the period of 1995 to 2014. Autoregressive Distributed Lag (ARDL) model and vector error correction model (VECM) were used in this study to study the cointegration and causality analysis. Unit root test and stability test were adopted to increase the reliability and accuracy of the model. The analysis shows that parity purchase power (PPP) has a positive relationship with inflation (INF) in both long-run and short-run. Result shows in long-run, the increment of 1% for both energy consumption (EC) and PPP will result -1.12% and 0.032% effect respectively towards inflation in Indonesia. While for 1% increase in energy consumption is expected to give 1.5297% increment on inflation in short-run cases. Granger causality test shows only unidirectional causality between parity purchase power and inflation in both the long-run and short-run. Energy consumption only shows unidirectional causality toward inflation in the long-run. Overall mean increase of PPP or EC has a single direction influence on the inflation rate. The study can aid policy planning in eradication energy poverty.

Keywords: Energy poverty, ARDL, Granger causality

1. Introduction

Urbanization is a transition to improving our current world civilization. With the aid of education and technology, human gains the ability to communicate with others from far. Technology shortens the distance between people from other nations. Hence, energy has been the key to excel urbanization and improves human living standards. The relationship between economic and energy consumption has been a wide research topic since the past few decades. Poverty alleviation project has been part of the topic to discuss in World Summit on Sustainable Development in 2002 [1]. Access to sustainable energy had been acknowledged as an important element in poverty alleviation. The concept is to ensure people can obtain affordable energy services in daily life. Hence, energy poverty is considered part of the main section of the poverty issue. Developing countries are mostly cases that are trapped in the energy poverty problem.

According to the International Energy Agency (IEA) 2017, the Asia region has around 439 million people who lack access to electricity with India is the rate countries [2]. Indonesia is the largest coal exporter and 8th in natural gas export among the ASEAN. Fossil fuel is an important income for national economic activities. Approximately 130 million Indonesians use raw biomass and kerosene as daily cooking or lighting purpose according to the report. The access to electricity in Indonesia is 97.01% but the access to clean fuel and technology for cooking is 56.64% in 2014 [3]. The energy poverty issue has long existed in Indonesia and facing a lot of challenges. Indonesia territories are a

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combination of more than 16000 islands [2]. The rural area population percentage is relatively high for Indonesia. The conventional power grid is hardly supplied to all places to provide sustainable and reliable electricity. However, with the electricity subsidies policy, people still at an affordable rate to access electricity. Hence, the ability to obtain affordable energy service is one of the factors where people still prefer raw biomass for cooking [4]. The government had endorsed multiple policies in aid to eradicate poverty issue including energy poverty [4]. This paper examines the causal relationship of income, economics and energy for Indonesia. This approach can aid policymaker by act as references in future policy. The remaining of this paper is organized as follows. Section 2 shows the previous energy poverty-related study. Section 3 shows the data selected and the methodology. Section 4 shows the result and discussion and the final section is the conclusions.

2. Energy Poverty

Energy poverty is a global scale threat that stopping humans to leap forward to a better living standard. Current energy poverty research is mostly survey-based analysis, conceptualization, regression, multi-dimensional energy poverty index and study case.

India's government implemented a renewable energy policy to alleviate the energy poverty problem as reported by Venkateswaran et. al [5]. Localize, increase affordability and saturation of energy services is the research keyword and mapping done to show the co-relationship of each other. Anjali Bhide and Carlos Rodríguez Monroy also presented a review on the energy poverty issue in India and the role of renewable energy [6]. The existing electrical policy of India gives a clear picture of the effect of the policy upon the current energy scenario in India. The author urges the need to introduce renewable energy to aid the current energy policy to eradicate energy poverty. The promising or potential renewable energy for India such as wind, solar, hydro and biogas been discussed in terms of rural area application.

Malakar et al discussed the trend of people are tending to remain using old ways of cooking even provided with the clean energy cooking method [7]. The conceptualization method can be a solution on motivating people to use clean energy cooking and emphasis on the harm of solid fuel related to cooking habit. Bingdong Hou, Hua Liao and Junling Huang proposed using income and assets for evaluating energy poverty based on cooking fuel in china [8]. The outcome shows more than 50% of rural area households using traditional biomass as the main cooking fuel. OLS based multinomial logit regression was used to analyse the collected data and the results show a transition from solid fuels to clean fuels were influenced by economic poverty.

Multidimensional energy poverty (MEP) study were done by Oihana Aristondo and Eneritz Onaindia based on three energy indicators which are the ability to keep the home adequately warm, the arrears on utility bills and the presence of a leaking roof, damp walls or rotten windows [9]. Besides the indicator use, the authors also included the analysis of the effect of energy poverty on poor people living conditions. The result shows increasing of 25% of poor people who suffer two or three of the indicator problems in the ten years. Hence, alert been put on to politicians on the effort of alleviation energy poverty throughout policy strategy.

Tabitha Atieno Olang etal also adopted MEP index to reflect the energy poverty condition in Kisumu City, Kenya [10]. The indicators applied were cooking fuel, indoor pollution, electricity access, household appliance, entertainment, education and telecommunication. MEP index method shows the advantages of analysis of energy poverty on household level without correlated indicator concern.

Monyei et Al. discussed the generation, transmission and distribu-tion of electricity of Nigeria [11]. The northern region was identi-fied as a low grid connection and low economic activity which shows the effect of energy poverty. Renewable energy potential for Nigeria such as solar and wind energy also has been done sta-tistically. Thomson et al. used European Union statistics on income and living conditions (EU-SILC) as the measurement of energy poverty in Europe [12]. Access, affordability, flexibility, energy efficiency, needs and practices were the factors that concluded by the author that caused energy poverty.

Sergio Tirado Herrero reviewed energy poverty indicator in terms of the methods [13]. The research emphasized on a single indicator in evaluating energy poverty. The author concluded that energy poverty needs to consider the actual / required energy expenditures, balance of income and energy expenses of a household. Hosier and Kipondya showed energy poverty that happens in Tanzania with three case study cities [14]. Data collected was categorized based on the household income, type of biomass usage and price for Dar es Salaam, Mbeya and Shinyanga. The finding shows that kerosene is more promising than other energy sources in the situation in terms of price and avoid raw materials for combustion. Tanzania government introduced kerosene subsidy policy also to reduce the living cost of poor people in Tanzania from energy poverty.

The energy poverty problem in the rural area of Brazil also was addressed by Marcio Giannini Pereira et al. in terms of electrification [15]. The energy poverty evaluated based on energy consumption, physical weakness, isolation, income, vulnerability environment and adaptation to ensure fulfill multidimensional evaluation. Analysis of electrified and non-electrified with two phases (Brazil policy before and after) on energy poverty issues also were done and results show a positive impact on energy consumption in rural electrification as the percentage energy poverty decreases. Abdul Waheed Bhutto and Sadia Karim provided evidence that energy supply is one of the keys to poverty alleviation in the current decade [16]. Hypothesis-based analysis on effects of improving energy facility and categorize the energy services related to the social and environmental impacts. Result concluded with a statement that poor people spend more time and money to get energy services. Resultant people are more prefer wood fuel as the main fuel due to affordability and accessibility.

These studies reflect that energy poverty is highly related to the economy, income and the availability of electricity. This paper selected variables which are highly affected by the outcome study from the literature review.

3. Data and Methodology

In this paper, all the data collected were taken from World Development Indicator. The time period is from 1995 to 2014 due to availability [3]. The three variables selected were energy use (kg of oil equivalent per capita), gross domestic product- purchasing power parity (constant 2011 international \$) and inflation-consumer prices (annual %). Abbreviations of each data are EC, PPP and INF. The selected data on purpose to find the causal relationships between energy, economic and income. The study used all data in natural logarithm form which helps to induce stationarity in the variance-covariance matrix. The quarterly data method was used to estimate the model in which time period changes from 1995Q1 to 2011Q4.

3.1 Unit Root Test

In time series analysis, the order of integration is important for each data set in terms of stationary states. Augmented Dickey-fuller test (ADF) and Philips and Perron test (PP) were used to analyse the stationary states of each variable. ADF test refers to the probability of *t*-statistic value and compares to the critical value of significance level of 1%, 5% and 10%. PP test has a similar function but has advantages of eliminating error that occurs in serial correlation and heteroscedasticity.

3.2 Proposed Model

The study adopted multivariate granger causality to identify the connection between energy and economics [17-18]. The framework was proposed as given in (1).

$$In(ec) = \beta_0 + \beta_1 In(ppp) + \beta_2 In(\inf) + \varepsilon_t \qquad (1)$$

where,
ec = Energy use (kg of oil equivalent per capita)
ppp = GDP, PPP (constant 2011 international \$)
inf = Inflation-consumer prices (annual %)
ε_t = Standard error term

3.3 ARDL Bound Test Model

Throughout the model in (1), ARDL is adopted for long-run and short-run investigations. ARDL model has the advantages of does not require variable to integrate at first order and can adopt in small sample size data [19]. The proposed framework ARDL model needs to include short-run dynamics to investigate both long and short-run cointegrations [19-21]. Hence, the complete ARDL estimation model is shown in (2).

$$\begin{aligned}\Delta In(\mathrm{ec}) = \alpha_0 &+ \sum_{i=1}^{n}\alpha_1 \Delta In(ec)_{t-i} + \sum_{i=1}^{n}\alpha_2 \Delta In(ppp)_{t-i} \\ &+ \sum_{i=1}^{n}\alpha_3 \Delta In(\inf)_{t-i} + \beta_1 (ec)_{t-i} \\ &+ \beta_2 (ppp)_{t-i} + \beta_3 (\inf)_{t-i} + \varepsilon_t\end{aligned} \qquad (2)$$

The first half equation with α_i is part of the long-run cointegration test while β_i is for the short-run cointegration test. The null hypothesis for this method is $H_0 = \beta_1 = \beta_2 = \beta_3 = 0$ and $H_1 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq 0$ .The calculated result emphasis on the F-statics which is the indicator of existing of long-run relationship occur vice-verse. If the *F*-statists value if higher than the 1% significant bound, H_1 is accepted which means short- run cointegration exists. The existence of short-run cointegration enables analysis of granger causality test. Granger causality test helps to identify the directional of the causality between variables [22]. Hence, the vector error correction model (VECM) based granger causality test is used to identify the long-run and short-run causality direction. VECM mostly commonly used in terms of finding cointegration of variable which has stochastics trend. The augmented form of granger causality test is proposed as shown in (3).

$$(1-B)\begin{bmatrix} ec_t \\ ppp_t \\ \inf_t \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix} + \sum_{i=1}^{p}(1-B)\begin{bmatrix} d_{11i} & d_{12i} & d_{13i} \\ d_{21i} & d_{22i} & d_{23i} \\ d_{31i} & d_{32i} & d_{33i} \end{bmatrix} \times \begin{bmatrix} ec_{t-i} \\ ppp_{t-i} \\ \inf_{t-i} \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \end{bmatrix}\left[EC_{t-1}\right] + \begin{bmatrix} \gamma_{1t} \\ \gamma_{2t} \\ \gamma_{3t} \end{bmatrix} \quad (3)$$

Form the model, (1-B) is the lag operator, c is the constant, d is the parameter to be estimated, EC_{t-1} is the error correction term and also represents long-run coefficients. λ is the short-run coefficients. γ is uncorrelated random disturbance since this is a stochastic model. T-statistic significance is the indicator to evaluate the direction of causality.

4. Result and Discussion

Table 1 shows the univariate analysis data of the selected variable for the designed model. All variables show normal distributed and positive skewness which shows the scatter data are mostly above mean. EC shows a positive correlation with PPP but negatively correlated to INF. PPP also shows a negative correlation to INF.

Table 1 - Univariate analysis and correlation index

Variables	EC	INF	PPP
Mean	1.429546	0.528679	7.024621
Median	1.413293	0.482111	7.009863
Maximum	1.514656	1.061039	7.146278
Minimum	1.368241	0.297263	6.940092
Std. Dev.	0.043003	0.156711	0.064210
Skewness	0.551470	1.583059	0.414012
Kurtosis	1.803858	5.909592	1.813403
EC	1		
INF	-0.3276	1	
PPP	0.7088*	-0.5005	1

As proceed to the next step that is unit root test before executing the ARDL bound test. The variables tested with both approaches that are ADF result is shown in Table 2. In the ADF test method, all results reach stationary after first differences in intercept and trend and intercept cases expect PPP. The result is then compared with the PP test to further validate the hypothesis. ***, ** and * is the indicator of 1%, 5% and 10% significance level respectively.

Table 2 - Unit root test (ADF approach)

Variables	Intercept		Trend and intercept	
	level	First differences	level	First differences
EC	-0.8187	-3.2513**	-1.7901	-3.3303*
INF	-1.6989	-7.0348***	-4.5665**	-3.5659**
PPP	1.3525	-2.1047	-8.9092***	-2.9095

In the Phillips–Perron test, all results reach stationary after first differences. In both cases, all show stationary with 1% significant level. Hence, all variable is proven to reject the null hypothesis and become stationary at integrated of order one. Table 3 shows the result of the unit root test with the PP test.

Table 3 - Unit root test (PP approach)

Variables	Intercept		Trend and intercept	
	level	First differences	level	First differences
EC	-0.7582	-4.7918***	-1.6476	-4.8146***
INF	-2.9028*	-5.1317***	-3.2434*	-5.0986***
PPP	0.8305	-4.1827***	-1.4790	-4.3883***

Lag length criteria selection were done based on the best model with Akaike Information Criteria (AIC) due to the small sample size adopted in this research. The result of the best-fit lag length selection is shown in Fig. 1. The result shows the best lag length models out of 20 best models is 2, 2, 2 with -7.2203.

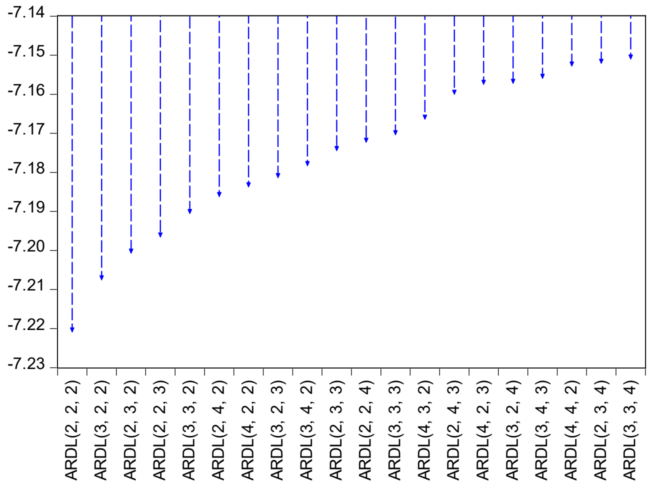

Fig. 1 - AIC based best lag length model (best 20)

Table 4 shows the result of the ARDL bound test with different variables used as the dependent variable. ARDL bound test was adopted to investigate the existence of the short-run relationship. The result shows that only the INF case shows the existence of short-run relationships while others are no even reach the 10% significant level. For the EC and PPP show no short-run cointegration in which the causality test needs to be done in a different approach.

Table 4 - ARDL bound test for all variables

Dependent Variables	F-statistic	Signif
EC	2.027770	-
INF	8.663059	>1%
PPP	2.421216	-

Table 5 shows the long-run relationship result in the model with INF as the dependent variable. The result shows that there is a positive impact of PPP towards INF. The rising by 1% of PPP will give 0.032% of increment for INF. This shows that the purchasing power of people in Indonesia has low influence on the inflation incident. Negative impact happens between the INF and EC. The increase of 1% of EC results in the decrease of INF by 1.12%. The result is proven the hypothesis that energy consumption has a strong influence on the economy of a nation. Indonesia has invested a lot of resources on energy policy. The supported energy fuel such as nuclear (1997), oil and gas (2001), geothermal (2003), National long-term Development Planning (2007), Mining and coal (2009) and others up to date. As mention that Indonesia rich in natural resources export, results obtain are reasonable and can show the level of influence. The stability of the model was further diagnosed using serial correlation and heteroscedasticity test. The result shows strong positive significance with a probability of 0.9979 and 0.601.

Table 5 - Long-run analysis

Variables	Coefficient	Std.error	T-statistic
PPP	0.0316	0.4502	0.0702
EC	-1.1228	0.5814	-1.9310
c	2.0128	2.5820	0.7795

EC = INF - (0.0316*PPP -1.1228*EC + 2.0128)

Stability diagnostic	Serial correlation	Heteroscedasticity
	0.0021(0.9979)	0.8305(0.6010)

Table 6 shows the short-run estimation of using the ARDL approach. The results show fairy significance in all cases. The increasing of 1% of the current period of INF shows the increment of 0.15% of future INF as other variables keep constant. PPP and EC also show a positive impact on the INF. Parity purchase power has a high impact with 6.9% and a high significance level. Energy consumption also has a high significant level with 1.53% influence on inflation. The error correction shows negative and statistically significant with -0.25 at 1% level. This ensures the short-run model is corrected with 1% towards the long-run equilibrium path.

Table 6 - Short-run analysis

Variables	Coefficient	Std.error	T-statistic
D(INF)	0.1455**	0.0704	2.0667
D(PPP)	6.8989***	2.4053	2.8682
D(EC)	1.5297***	0.5670	2.6979
EC_{t-1}	-0.2514***	0.0418	-6.0209

The stability of the ARDL model was tested with CUSUM and CUSUMsq test. The result shows that the proposed model bound between the critical region for the CUSUM test as shown in Fig. 2. Meanwhile, for CUSUMsq square statistics are not perfectly bound between the critical bound region as shown in Fig. 3. The region of outbound is expected to have a structural break in inflation for period 1999Q1 to 2014Q4. However, the result of the Chow Forecast test shows that there is no significant structural break in between the period [23]. Hence, The ARDL estimation model considers stable and reliable.

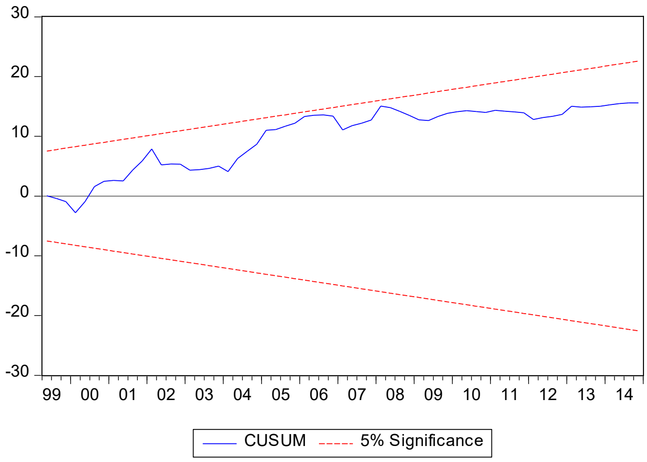

Fig. 2 - CUSUM test

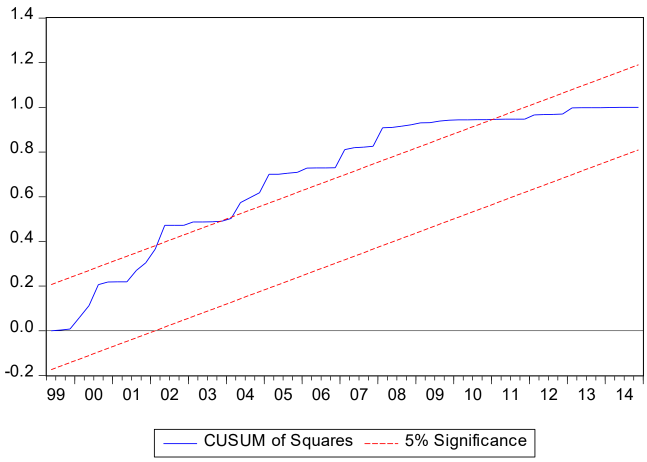

Fig. 3 - CUSUM square test

The result of the VECM based granger causality test is shown in Table 7. Among the short-run granger causality, only INF and PPP show significant causality direction at 1% level. For the long-run granger causality test, INF shows a significant causality relationship with EC and PPP at 1% level.

Table 7- VECM long-run and short-run causality analysis

Causality	Short-run granger			Long-run granger
	D(EC)	D(PPP)	D(INF)	ECM
D(EC)	-	0.3635 [0.8338]	0.0645 [0.9683]	0.0026 [0.3132]
D(PPP)	2.5171 [0.2841]	-	8.500330 [0.0143]	0.00834 [2.8207]
D(INF)	1.4580 [0.4824]	1.0653 [0.5871]	-	-0.3548*** [-5.8830]

Hence, the direction of the causality diagram was plotted as shown in Fig. 4. The arrow shows the causality direction of the long-run and the dotted arrow shows the causality direction of the short-run. Party purchase power has both long and short-run causality toward inflation. Besides that, energy consumption also has a long-run causality towards inflation.

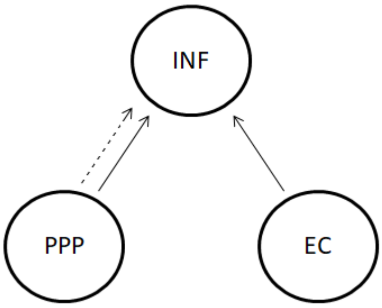

Fig. 4 - Directional relationship (granger causality)

5. Conclusion

This study used the ARDL model to examine the cointegration relationship between energy consumption, parity purchase power and inflation for Indonesia's case in the period of 1995 to 2014. The long-runs analysis outcome shows that the income or purchase ability of the Indonesian is relatively positive relation. This implies that economic improvement does not significantly help reduce the inflation rate of Indonesia. However, increasing of energy consumption significantly drives inflation to a lower rate. In the case of short-run analysis, all variables show significant positive as other variables keep constant. Besides that, parity purchase power has both long-run and short-run unidirectional causalities while energy consumption has a unidirectional causality in the long-run. From the economic aspect, the power of purchase and inflation is closely related. Increase Indonesian basic income to increase purchase ability should reduce inflation but the analysis shows in a different direction. Overall, analysis shows that increasing energy consumption did strongly influence inflation which results int affordable goods and services. The analysis is helpful for the policymaker to make future policy by understanding long-run and short-run relationship.

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