The Damaging Growth: An Empiric Evidence of Environmental Kuznets Curve in Indonesia

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ABSTRACT

This study examines the short-run and long-run relationships between economic growth, carbon dioxide (CO₂) emissions and energy consumption within a sample period of 1990-2016. The study used autoregressive distributed lag approach to test the cointegration relationship and Granger vector error correction model causality test to investigate the direction of causality. This study does not support the hypothetical relationship (environmental Kuznets curve) for a significance level of 5%. The long-run test of Granger causality shows that there is a two-way causal relationship of economic growth, CO₂ emissions, and energy consumption. This result indicates that a reduction in energy consumption is an effective way to control CO₂ emissions but will simultaneously impede economic growth. Therefore, setting suitable policy related to efficient consumptions of energy resources and renewable energy resources is necessary.

Keywords: Environmental Kuznets Curve, Carbon Dioxide Emissions, Energy Consumption

JEL Classifications: Q42, Q43, C10

1. INTRODUCTION

The relationship between energy consumption, economic development, and environmental damage has increasingly been discussed in various studies lately triggered by the increasing concern for environmental damage along with increasing awareness of global warming and climate change.

Energy is one of the most important factors in transforming the country from a developing to a developed one. But at the same time, energy consumption can have a negative impact on the environment (Saboori and Sulaiman, 2013). Intensive fuel consumption, especially fossil fuels, is the main cause of impact on air environment. The combustion process of fossil fuels emit air pollutants and compounds, such as total suspended solids (dust), carbon monoxide, total hydrocarbons, nitrogen oxide, sulfur oxide, lead particles, and photochemical oxidants (Soedomo, 2001). Indonesia is experiencing various environmental problems including climate change threat caused by rapid economic growth and extensive consumption of natural resources especially the burning of fossil fuels (Sugiawan and Managi, 2016). The World Bank estimates that economic loss due to climate change in Indonesia is to reach 2.5-7% of GDP by 2100. Meanwhile, the health impact of air pollution could cost more than US$ 400 million per year (Leitmann, 2009). An alternative to do to overcome emission problems is by reducing energy consumption especially fossils energy consumption. However, this reduction will lead to a “trade-off” for economic growth, which enables unexpected economic growth (Lotfalipour et al., 2010) as the consequence of significant relationship between economic growth, energy consumption, and carbon dioxide (CO₂) emissions.

The dependency on fossile energy in fulfilling domestic consumption is still high - 48% on oil, 18% on natural gas and 30% on coal - of total national energy consumption (International Energy agency (https://www.iea.org/statistics/), 2014; US Energy Information Administration (EIA) data, 2014). Similarly, high dependency on fossil fuels is also found out in the electricity sector. In 2014, the total power plant was around 288 TWh, 88%
Environmental Kuznets curve (EKC) hypothesis testing is becoming increasingly important to prove whether economic growth is the solution to future environmental problems without any policy intervention. A number of studies have been conducted to investigate the existence of the EKC hypothesis regarding CO\(_2\), both for developed and developing countries. However, most of them depend on cross-country panel data analysis. Consequently, it is only able to describe the general conclusions of the EKC hypothesis which tend to ignore the complexities of the economic environment and the historical experience of each country (Ang, 2008; Hill and Magnani, 2002; Dinda, 2004; Stern, 2004). Those studies emphasized the need for a specific EKC study relating to CO\(_2\) for a particular country to provide in-depth analysis. This is necessary to develop effective energy and environmental policies for each country. Therefore, this study aims to find empirical evidence from the EKC hypothesis for CO\(_2\) in Indonesia by examining the relationship between economic growth and environmental degradation. In addition, a high correlation between economic growth, energy consumption and environmental degradation is an interesting subject to reveal (Bhattarai and Hammig, 2001; Bulte and Soest, 2001; Dasgupta et al., 2002; Hasan et al., 2012) [Figure 1].

2. LITERATURE REVIEW

The 1971 Nobel Prize winner, Simon Kuznets, stated that when per capita income increases, income inequality also initially increases but then starting to decline after reaching the turning point (Kuznets, 1955). The inverted U-shape relationship between per capita income and income inequality is illustrated by a bell-shape curve, a popular phenomenon known as the Kuznets Curve. Similar inverted U-shape relationship is also found between per capita income and environmental degradation in the early 1990s through cross-country analysis (Grossman and Krueger, 1991; Shafik and Bandyopadhyay, 1992; Panayotou, 1993). Since then, the EKC hypothesis has become a topic that has been widely used as theoretical and empirical literature. The inverted U-shape relationship between economic growth and environmental degradation is explained by the EKC, in which environmental degradation increases along with initial economic growth and decreases at a certain point where the economy reaches a specific high level of income.

According to the EKC hypothesis, the level of environmental pollution initially increases due to economic growth. It then declines after GDP per capita reaches a threshold value (Panayotou, 1993). Therefore, this hypothesis implies a dynamic process in which structural changes occur along with economic growth. Grossman and Krugger (1991) first clarified how the EKC emerged. They explored that economic growth affects environmental quality through three channels: (i) Scale effects, (ii) structural effects, and (iii) technological effects. Figure 2 shows EKC in periods (i), (ii) and (iii) (Panayotou, 1993).

![Energy Mix in Indonesia, 2014](image1)

![Environmental Kuznets curve](image2)
effective. From these stages it can be concluded that environmental pollution initially increases and then decreases as a result of scale effect, structural transformation and technology that emerge along with economic growth.

Empirical evidence supporting the elimination of CO₂ emissions and economic growth has not been conclusive compared to other air and water pollutants (Selden and Song, 1994; Shaﬁk, 1994; Sasana and Aminata, 2019) other pollutant such as sulphur (De Bruyn, 1997; Kaufmann et al., 1998; Rothman, 1998) or deforestation (Rothman, 1998; Koop and Tole, 1999) have been approved experienced EKC and rarely discussed on article nowadays. Some studies have found that EKC (CO₂) does occur (Robers and Grimes, 1997; Cole et al., 1997; Schmalensee et al., 1998; Galeotti and Lanza, 1999; Azomahou et al., 2006; Apergis and Payne, 2009; Lean and Smyth, 2010; Saboori and Sulaiman, 2013; Sugianto and Managi, 2016) or do not support the EKC hypothesis (Ibrahim, 2016; Zakaria, 2017; Sasana and Aminata, 2019).

Research on EKC in Indonesia has been conducted by Saboori and Sulaiman (2013). Their research aims to examine cointegration and causal relations between economic growth, CO₂ emissions and energy consumption in 5 ASEAN countries. The approach used is autoregressive distributed lag (ARDL), with the time span of data used was 1971-2009. The results showed that the EKC hypothesis was not conﬁrmed. Sugianto and Managi (2016) examined the relationship of economic growth and CO₂ emissions with renewable energy as the control variable. The ARDL method was also used for the 1971-2010 study sample period. The results showed that the EKC was proven in the long-run with a GDP per capita turning point of USD 7.729. They also provided suggestions for research on EKC should include renewable energy in the model. Sasana and Aminata (2019) conducted a study to analyze the effect of energy-based economic growth on CO₂ emissions, with energy subsidies, energy consumption, population growth, and economic openness as exogenous variables. The study used Multiple Linear Regression for analysis approach. The result showed that EKC is not proven in Indonesia. Economic growth, primary energy consumption, and population growth positively affect CO₂ emissions, while consumption of renewable energy negatively affects CO₂ emissions.

3. DATA

The data for this study were selected based on the availability for all study series. The study years used in this study are from 1990-2016. CO₂ emissions were measured in metric tons of CO₂ per person. Real GDP is GDP per capita based on year 2010 price in US dollars. Per capita energy consumption is the aggregate energy consumption in tonne of oil equivalent (toe) or the equivalent ton of oil, which then is divided by the total population of Indonesia. All energy data and CO₂ emissions per capita are obtained from the US Energy Information Administration (EIA) available on the website (https://www.eia.gov/). As for real GDP per capita and total population are taken from the World Development Indicators (WDI) for the study period.

4. RESEARCH METHODS

Following the latest research method by Acaravci and Ozturk (2010), Saboori and Sulaiman (2013), Sugianto and Managi (2016), this study used the ARDL approach to cointegration developed by Pesaran et al. (2001) and the vector error correction model (VECM)-based Granger causality method to investigate the long-run and causal relationship between economic growth, CO₂ emissions and aggregate energy consumption in Indonesia during 1990-2016.

4.1. ARDL Test

The ARDL approach is chosen for this study to examine the long-run relationship between CO₂ emissions, economic growth and energy consumption in aggregate. The equation is specified as

\[ \ln E_t = \beta_0 + \beta_1 \ln Y_t + \beta_2 \ln Y_t^2 + \beta_3 \ln E_t + \epsilon_t \]  \hspace{1cm} (1)

where \( E \) is CO₂ emissions per capita, \( Y \) represents real per capita income, \( EN \) stands for energy use per capita and \( \epsilon \) is an error term. Based on the EKC hypothesis, the sign of \( \beta_1 \) is expected to be positive, while the negative sign is expected for \( \beta_2 \) with a significant level of signiﬁcance. As for the energy consumption level variable, because higher energy consumption leads to greater economic activity and directly stimulates CO₂ emissions, then \( \beta_3 \) is expected to be positive.

Equation (1) shows a long-run relationship. To implement the ARDL cointegration approach into this model, first the short-run dynamics need to be added to the long-run. Short-run equation that corresponds to long-run equation (1) is written as equation (2)

\[ \Delta \ln E_t = \alpha_0 + \sum \alpha_1 \Delta \ln E_{t-k} + \sum \alpha_2 \Delta \ln Y_{t-k} + \sum \alpha_3 \Delta \ln E_{t-k} + \phi_1 \Delta \ln E_{t-1} + \phi_2 \Delta \ln Y_{t-1} + \phi_3 \Delta \ln E_{t-1} + \epsilon_t \]  \hspace{1cm} (2)

Next, the term lag in each equation is substituted by the lag value of ECT built with the same optimal lag number selected by AIC or SBC. ECT shows the speed of adjustment and shows how quickly the variable returns to long-run equilibrium and must have a statistically signiﬁcant coefﬁcient with a negative sign, then a cointegration relationship exists. The general ECM (Error Correction Model) of equation (2) is formulated as equation (3).

\[ \Delta \ln E_t = \alpha_0 + \sum \alpha_1 \Delta \ln E_{t-k} + \sum \alpha_2 \Delta \ln Y_{t-k} + \sum \alpha_3 \Delta \ln E_{t-k} + \theta \epsilon_{t-1} + \epsilon_t \]  \hspace{1cm} (3)

In the final step, to examine the suitability of the model several diagnostic tests such as the normality test for heteroscedasticity and autocorrelation are conducted. Furthermore, following Pesaran et al. (2001) Cumulative amount (CUSUM) and cumulative squared (CUSUMSQ) tests are conducted to test the stability of the long and short-run estimate.

4.2. VECM Granger Causality

Cointegration approach is employed to test whether there is a long-run relationship between variables. Meanwhile, to test the
direction of causality between carbon emissions, economic growth and energy consumption, the VECM Granger test is conducted. Granger’s approach (1969) based on the VECM answers the question whether x causes y or y to cause x. To find out the long-run relationship between variables in the model, the term Lagged Error Correction (ECTt - 1) is used as an indicator that can be obtained from Long-run cointegration relationships. Meanwhile, short-run causal relationships are detected through the F-statistics significance test and Wald test of the relevant coefficients. Criteria such as AIC and SBC to choose the appropriate lag length are employed in this study.

4. E5. MIPRICAL RESULTS

Unit root tests were conducted to find the stationarity of the data using the Augment Dickey-Fuller (ADF) test plus Phillips-Perron (PP) (1988). Table 1 summarizes the results of the ADF and PP unit root tests at the level I (0) and First Difference I (1) levels. The results show that all stationary variables at the First Difference I (1) level. This test results validate the use of the ARDL approach for cointegration. The optimal lag in this study was determined using AIC with the ARDL model (1, 1, 0, 3). This model was chosen because it has a smaller error compared to other ARDL models. Next, the cointegration test using Bounds Testing Cointegration is conducted. Table 2 summarizes the results of the cointegration test of the model used.

F-statistic value is 6.35, where the value is greater than I (0) and I (1) Critical Value Bounds, so it can be concluded that the research variable has cointegration in the long-run. After cointegration is identified, estimation is then carried out. Table 3 provides long-term estimation results based on the ARDL approach with diagnostic test results. The results show that EKC does not occur in Indonesia.

Variables of GDP per capita (Y), and per capita energy consumption (EN) have a linear effect on CO\textsubscript{2} emissions significantly which means every increase in GDP per capita and per capita energy consumption would actually increase CO\textsubscript{2} emissions as in the EKC hypothesis at an early stage. This result is in line with research by Saboori and Sulaiman (2013) that EKC does not occur in Indonesia in the short-run. Next, the cointegration test using Bounds Testing Cointegration is conducted. Table 2 summarizes the results of the cointegration test of the model used.

The variable GDP per capita squared (Y\textsuperscript{2}) has a coefficient marked negative but not significant for alpha 5%. It can be concluded that the behavior of the variable GDP per capita and CO\textsubscript{2} emissions form an inverted U-shape curve with a turning point when Indonesia’s per capita income reaches approximately 7.819 USD. This figure is not found in the sample year used. The previous sample (in 2016) of Indonesia’s per capita income based on constant prices in 2010, which was 3,974 USD. This finding is consistent with the findings of Jalil and Mahmud (2009) who reported EKC turning points outside the observed sample period. Iwata et al. (2010) argue that the probability of finding a turning point outside the sample period observed in developing countries is higher than in developed countries. The findings of the turning point from EKC are also not much different from the findings of Sugiawan and Managi (2016) which show that EKC is proven in the long run with a GDP per capita turning point of USD 7.729. The diagnostic test results of serial correlation, normality and heteroscedasticity show residual normality, an absence of serial correlation and no heteroscedasticity.

Short-term estimates are presented in Table 4 along with diagnostic tests. The results show that the EKC hypothesis is also not valid in the short-run in Indonesia. This result is similar with that of Saboori and Sulaiman (2013) that EKC does not occur in Indonesia in the short-run. The possible underlying reason is that EKC is a long-run phenomenon (Dinda, 2004). No evidence of EKC in the short-run is rational because CO\textsubscript{2} emissions are a form of global pollution that increases or decreases over a long period. EKC itself, until now, is not able to guarantee whether all pollution indicators follow the inverted U-shape hypothesis. This argument arises based on

Table 1: Results of unit root tests

| Level  | ADF test statistic | PP test statistic |
|--------|--------------------|------------------|
|        | Intercept          | Trend and Intercept | Intercept  | Trend and Intercept |
| LnE    | -1.74588           | -2.374355         | -1.44913  | -2.199589 |
| LnY    | 0.050495           | -1.284146         | -0.059253 | -1.516996 |
| LnY\textsuperscript{2} | 0.211249           | -1.176677         | 0.086874  | -1.40923  |
| LnEN   | -1.824849          | -1.981066         | -1.899589 | -1.98706  |

| First difference | ADF test statistic | PP test statistic |
|------------------|--------------------|------------------|
|                  | Intercept          | Trend and Intercept | Intercept  | Trend and Intercept |
| LnE              | -6.878768***       | -7.166992***      | -6.878768** | -7.181506*** |
| LnY              | -3.68482**         | -5.819191***      | -3.65948**  | -3.62007**  |
| LnY\textsuperscript{2} | -3.6665**         | -5.935508***      | -3.643175** | -3.62597**  |
| LnEN             | -4.906168***       | -5.17418***       | -4.905578** | -5.183035** |

***, ** and * indicate 1, 5 and 10 percent of significance, respectively. Optimal lag is automatically selected using Schwarz information criteria for the ADF test and the bandwidth used is Newey – West for the PP test. Source: Data processed, 2019
local pollution forming other greenhouse gases such as sulfur oxide, which follow an inverted U-shape (Paraskevopoulos, 2009).

\[
\text{ECM} = \text{EM} - (0.0336^*\text{LNY} - 2.7287^*\text{LNY}^2 - 22.3007^*\text{EN} - 9.3020)
\] (4)

To check the short and long-run coefficient stability, CUSUM and CUSUMSQ techniques are used. Figure 3 presents plots of CUSUM and CUSUMSQ tests for all models (data processed, 2019). The results imply that the estimated parameters are stable during that period.

The long-run relationship between carbon emissions, economic growth and energy consumption shows that there must be at least one direction in Granger causality. The results of the causal relationship between variables using the VECM-based Granger causality test are summarized in Table 5.

The long-run Granger causality test results show that there is a two-way Granger causality relationship between energy consumption and economic growth, CO2 emissions and energy consumption and CO2 emissions and economic growth. This finding is in line with the results of Pao and Tsai (2011) in Brazil, Pao et al. (2011) in Russia, Al-Mulali (2011) in 15 countries in the Middle East and Northern Africa (Middle East North Africa), Saboori and Sulaiman (2013) in the Philippines, Indonesia and Malaysia, for a sample of 5 ASEAN countries, and Saboori and Sulaiman (2013) in Malaysia. This is proof that carbon emissions, energy consumption and economic growth are interrelated.

Meanwhile, the short-run Granger causality test shows that there is a two-way causality between energy consumption and carbon emissions. The greater the energy consumption carried out will lead to greater carbon emissions, and vice versa (Bashir et al., 2019). In addition there is also a one-way relationship between economic growth and carbon emissions and economic growth and energy consumption. This implies that reducing energy consumption in the short-run can reduce air pollution but disrupt or reduce economic growth. Furthermore, in the absence of short-run causality from economic growth and CO2 emissions it also indicates that economic growth is not the right solution to reduce CO2 emissions levels in the short-run.

**6. CONCLUSION**

1. The results of the study indicate that the EKC hypothesis statistically (α = 5%) did not occur in Indonesia for the study period. But the relationship behavior between variables supports the EKC hypothesis by forming an inverted U-shape and a turning point at the level of Indonesia’s per capita income reaching USD 7.819.

**Figure 3: CUSUM and CUSUMQ test results**

![CUSUM and CUSUMQ test results](image)

Source: Data processed, 2019
2. Empirical results show that energy consumption has a positive effect on CO₂ emissions in the long-run. Energy consumption also contributes to emissions in the short-run. This is reasonable, considering that Indonesia still relies on fossil energy sources. This means that diversification of energy sources is completely necessary.

3. Results in the short-run also indicate that the EKC hypothesis does not apply to Indonesia. This means that economic growth (without policy intervention) is not the right solution in reducing CO₂, both in the short and long-run.

4. ECTt - 1 coefficient has a coefficient with a negative sign as is expected and statistically significant. It means that CO₂ emissions will decrease over the period in Indonesia. The CUSUM and CUSUMSQ test results show that the short and long-run models are stable.

5. The results of Granger’s long-run causality show that there is a two-way causal relationship between economic growth and energy consumption, CO₂ emissions and economic growth, energy consumption and CO₂ emissions. This implies that any limiting policy related to energy consumption can reduce CO₂ emissions but at the same time will impede economic growth.

6. The results of short-run causality indicate the existence of two-way causality between energy consumption and carbon emissions. The greater the energy consumption, the greater carbon emissions will be, and vice versa. In addition, there is also a one-way relationship between economic growth and carbon emissions and economic growth and energy consumption.

7. The gap between current economic level and the EKC turning point estimate shows that the Indonesian Government must evaluate current energy consumption and environmental policies to get a lower and more even EKC. In addition, the current energy and environmental policies should also be accompanied by alternative strategies that make it possible to encourage more efficient use of energy.

REFERENCES

Acaravci, A., Ozturk, I. (2010), On the relationship between energy consumption, CO₂ emissions and economic growth in Europe. Energy, 35, 5412-5420.

Alam, J. (2014), On the relationship between economic growth and CO₂ emissions: The Bangladesh experience. Journal of Economics and Finance, 5, 36-41.

Al-Mulali, U. (2011), Oil consumption, CO₂ emission and economic growth in MENA countries. Energy, 36, 6165-6171.

Al-Mulali, U., Solarin, S.A., Ozturk, I. (2016), Investigating the presence of the environmental Kuznets curve (EKC) hypothesis in Kenya: An autoregressive distributed lag (ARDL) approach. Natural Hazards, 80(3), 1729-1747.

Ang, J. (2008), Economic development, pollutant emissions and energy consumption in Malaysia. Journal of Policy Modeling, 30, 271-278.

Apergis, N., Payne, J.E. (2009), CO₂ emissions, energy usage, and output in central America. Energy Policy, 37, 3282-3286.

Apergis, N., Payne, J.E. (2010), The emissions, energy consumption, and growth nexus: Evidence from the common wealth of independent states. Energy Policy, 38, 650-655.

Azomahou, T., Laisney, F., Phu, N.V. (2006), Economic development and CO₂ emissions: A non-parametric panel approach. Journal of Public Economics, 90, 1347-1363.

Bashir, A., Thamrin, K.H., Farhan, M., Mukhlis, M., Atiyatna, D.P. (2019), The causality between human capital, energy consumption, CO₂ emissions, and economic growth: Empirical evidence from Indonesia. International Journal of Energy Economics and Policy, 9(2), 98-104.

Bhattarai, M., Hammig, M. (2001), Institutions and the environmental Kuznets curve for deforestation: A cross-country analysis for Latin America, Africa, and Asia. World Development, 29(6), 995-1010.

Bulte, E.H., van Soest, D.P. (2001), Environmental degradation in developing countries: Households and the (reverse) environmental Kuznets curve. Journal of Development Economics, 65, 225-235.

Cole, M.A., Rayner, A.J., Bates, J.M. (1997), The environmental Kuznets curve: An empirical analysis. Environment and Development Economics, 2, 401-416.

Copeland, B.R., Taylor, M.S. (2003), Trade and the Environment. Princeton: Princeton University Press.

Dasgupta, S., Laplante, B., Wang, H., Wheeler, D. (2002), Confronting the environmental Kuznets curve. Journal of Economic Perspective, 16, 147-168.

De Bruyn, S.M. (1997), Explaining the environmental Kuznets curve: Structural change and international agreements in reducing sulphur emissions. Environment and Development Economics, 2, 485-503.

Dinda, S. (2001), A Note on Global EKC in Case of CO₂ Emission. Kolkata, Mimeo: Economic Research Unit, Indian Statistical Institute.

Dinda, S. (2004), Environmental Kuznets curve hypothesis: A survey. Ecological Economics, 49, 431-455.

Fabien, P. (2009), The environmental kuznets curve in a world of irreversibility. Economic Theory, 40, 57-90.

Galeotti, M., Lanza, A. (1999), Richer and cleaner? A study on carbon dioxide emissions in developing countries. Energy Policy, 27, 565-573.

Granger, C.W. (1969), Investigating causal relations by econometric models and cross-spectral methods. Econometrica: Journal of the Econometric Society, 37, 424-438.

Grossman, G.M., Krueger, A.B. (1991), Environmental Impacts of a North American Free Trade Agreement. NBER Working Paper 3914. NBER, Cambridge.

Grossman, G.M., Krueger, A.B. (1995), Economic growth and the environment. Quarterly Journal of Economics, 110, 353-377.

Hasan, M., Mahlia, T., Nur, H. (2012), A review on energy scenario and sustainable energy in Indonesia. Renewable and Sustainable Energy Reviews, 16, 2316-2328.

Hill, R.J., Magnani, E. (2002), An exploration of the conceptual and

Table 5: VECM Granger causality

| Variable | ΔlnEm | ΔlnY | ΔlnEN | ECTt-1 |
|----------|-------|------|-------|--------|
| ΔlnE     | -     | 3.264004 (0.0471) | 19.96182 (0.0002) | -0.545446 (−2.024811) |
| ΔlnY     | 0.009961 (0.9215) | -     | 1.965333 (0.1676) | -0.255369 (−1.20787) |
| ΔlnEN    | 10.40429 (0.0004) | 4.399914 (0.0269) | -     | -0.376114 (−3.820590) |

VECM: Vector error correction model. Source: Data processed, 2019.
empirical basis of the environmental Kuznets curve. Australian Economic Papers, 42, 239-254.

Ibrahim, D.M. (2016), Environmental Kuznets curve: An empirical analysis for carbon dioxide emissions in Egypt. International Journal of Green Economics, 10, 136-150.

Iwata, H., Okada, K., Samreth, S. (2010), Empirical study on environmental Kuznets curve for CO in France: The role of nuclear energy. Energy Policy, 38, 4057-4063.

Jalil, A., Mahmud, S. (2009), Environment Kuznet curve for CO emission: A cointegration analysis for China. Journal Energy Policy, 37, 5167-5172.

Kaufmann, R.K., Davidsdottir, B., Garnham, S., Pauly, P. (1998), The determinants of atmospheric SO2 concentrations: Reconsidering the environmental Kuznets curve. Ecological Economics, 25, 209-220.

Koop, G., Tole, L. (1999), Is there an environmental Kuznets curve for deforestation? Journal of Development Economics, 58, 231-244.

Kuznets, S. (1955), Economic growth and income inequality. American Economic Review, 45, 1-28.

Lean, H.H., Smyth, R. (2010), CO2 emissions, electricity consumption and output in ASEAN. Applied Energy, 87, 1858-1864.

Leitmann, J. (2009), Investing in a More Sustainable Indonesia: Country Environmental Analysis, CEA Series, East Asia and Pacific Region. Washington, DC: The World Bank.

Lotfalipour, M.R., Falahi, M.A., Ashena, M. (2010), Economic growth, CO2 emissions, and fossil fuels consumption in Iran. Energy, 35, 5115-5120.

National Energy Council. (2015), Executive Reference Data National Energy Management. Jakarta: National Energy Council.

Panayotou, T. (1993), Empirical Tests and Policy Analysis of Environmental Degradation at Different Stages of Economic Development, Working Paper WP238. Geneva: Technology and Environment Programme, International Labour Office.

Pao, H., Tsai, C. (2011), Modeling and forecasting the CO2 emissions, energy consumption, and economic growth in Brazil. Energy, 36, 2450-2458.

Pao, H.T., Yu, H.C., Yang, Y.H. (2011), Modeling the CO2 emissions, energy use, and economic growth in Russia. Energy, 36(8), 5094-5100.

Paraskevopoulos, D. (2009), An Empirical Analysis of the Environmental Kuznets Curve Hypothesis Over Two Centuries: Evidence from the UK and US. Master Thesis, University of Macedonia.

Pesaran, M.H., Shin, Y. (1999), An autoregressive distributed lag modeling approach to cointegration analysis. In: Strom, S., editor. Econometrics and Economic Theory in 20th Century: The Ragnar Frisch Centennial Symposium. Ch. 11. Cambridge: Cambridge University Press.

Pesaran, M.H., Shin, Y., Smith, R.J. (2001), Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16, 289-326.

Rauf, A., Liu, X., Amin, W., Ozturk, I., Rehman, O.U., Hafeez, M. (2018), Testing EKC hypothesis with energy and sustainable development challenges: A fresh evidence from belt and road initiative economies. Environmental Science and Pollution Research, 25(32), 32066-32080.

Robers, J.T., Grimes, P.E. (1997), Carbon intensity and economic development 1962-1991: A brief exploration of the environmental Kuznets curve. World Development, 25, 191-198.

Rothman, D.S. (1998), Environmental Kuznets curve-real progress or passing the buck? A case for consumption-base approaches. Ecological Economics, 25, 177-194.

Saboori, B., Sulaiman, J. (2013), CO2 emissions, energy consumption and economic growth in association of Southeast Asian nations (ASEAN) countries: A cointegration approach. Energy, 55, 813-822.

Saboori, B., Sulaiman, J. (2013), Environmental degradation, economic growth and energy consumption: Evidence of the environmental Kuznets curve in Malaysia. Energy Policy, 60, 892-905.

Sasana, H., Aminata, J. (2019), Energy subsidy, energy consumption, economic growth, and carbon dioxide emission: Indonesian case studies. International Journal of Energy Economics and Policy, 9(2), 117-122.

Schmalensee, R.L., Joskow, P.L., Ellerman, A.D., Montero, J.P., Bailey, E.M. (1998), An interim evaluation of sulfur dioxide emissions trading. Journal of Economic Perspectives, 12(3), 133-148.

Selden, T., Song, D. (1994), Environmental quality and development: Is there a Kuznets curve for air pollution emissions? Journal of Environmental Economics and Management, 27, 147-162.

Shafik, N. (1994), Economic development and environmental quality: An econometric analysis. Oxford Economic Papers, 46, 757-773.

Shafik, N., Bandyopadhyay, S. (1992), Economic Growth and Environmental Quality: Time Series and Cross-Country Evidence. Background Paper for the World Development 7 Report. Washington, DC: The World Bank.

Shahbaz, M., Dube, S., Ozturk, I., Jalil, A. (2015), Testing the environmental Kuznets curve hypothesis in Portugal. International Journal of Energy Economics and Policy, 5(2), 475-481.

Soedomo, M. (2001), Pencemaran Udara: Kumpulan Karya Ilmiah. Bandung: ITB Press.

Stern, D.I., Common, M.S., Barbier, E.B. (1996), Economic growth and environmental degradation: The environmental Kuznets curve and sustainable development. World Development, 24(7), 1151-1160.

Sugiawan, Y., Managi, S. (2016), The environmental Kuznets curve in ASEAN (ASEAN) countries: A cointegration approach. Energy, 55, 813-822.

Torres, M., Boyce, J.K. (1998), Income, inequality, and pollution: A reassessment of the environmental Kuznets curve. Ecological Economics, 25, 147-160.

Vincent, J.R. (1997), Testing for environmental Kuznets curves within a developing country. Environment and Development Economics, 2, 417-431.

Zakaria, Z. (2017), CO2 emissions, renewable energy and the environmental Kuznet curve, a panel cointegration approach. Renewable and Sustainable Energy Reviews, 72, 1067-1075.