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Article

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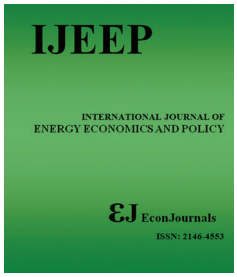

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Energy Subsidy, Energy Consumption, Economic Growth, and Carbon Dioxide Emission: Indonesian Case Studies

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ABSTRACT

In the globalization era, the process of economic growth must be supported by energy; although, it might be leave harmfully residual accumulation such carbon dioxide (CO_2) emissions to environment. The aim of this study was to analyze the effect of energy-based economic growth on CO_2 emissions. Estimation using multiple linear regression (multiple regression model) with ordinary least square method to analyze collected data. The results showed that economic growth, primary energy consumption, and population growth positively affected CO_2 emissions, while renewable energy consumption negatively affected CO_2 emissions. The environmental Kuznets curve hypothesis was not confirmed in Indonesian case, and economic globalization had no effect on CO_2 emissions.

Keywords: Environmental Kuznets Curve, Economic Growth, CO_2 Emissions, Renewable Energy, Globalization
JEL Classifications: H25, Q42, Q43

1. INTRODUCTION

A review of energy consumption causing environmental damage has led to economic growth. From macroeconomic perspective, a producer using input factors especially unrenewable energy left residual that usually pollute and threaten the environmental sustainability (Tiba and Omri, 2016). Therefore, to strengthen the environmental conservation program, every country applies economic planning supporting environmental sustainability (Merino-Saum et al., 2018).

Figure 1 shows that components driving economic growth of Indonesia is environmentally unfriendly energy. As the output of the Indonesian economy continues increasing in line with the positive economic growth, the CO_2 emissions also tends to increase. Yet, the use of renewable energy continues decreasing, indicating by a negative level of its growth rate. If this condition continues, the agenda of sustainable economic growth will be difficult to achieve.

Among the open economic trend, globalization has been expected to increase benefits for every participating country to enjoy economic growth. As the relationship between economic growth and the environmental degradation is not always positive, globalization is presumed to have an impact on the increasing carbon dioxide emissions. Everett et al. (2010) explained that the relationship between national income per capita and the level of environmental damage in a certain time span is formed as an inverted U-shape known as the environment Kuznet curve (EKC) hypothesis. Many scholars have referred the concept of EKC to underlie the study of sustainable economic development (Uchiyama, 2016).

However, the EKC hypothesis has not continuously been confirmed in every country. Azam and Khan (2016) found that low- and lower-middle income countries have confirmed the EKC hypothesis, while upper and high-income countries have not. Previously, Grossman and Krueger (1991) proposed that national income affects environmental conditions through three channels. The first is economic strength

based scale effect; when economic and technological structures of a country remain stable, increasing production in economy will increase environmental damage. The second is the composition effect; in the development stage, changes in the economic structure, from agrarian base to industrial base, will increase environmental damage. The third is the technique effect; better technological development will reduce environmental damage. Consequently, technological gap between developed and developing countries exists in terms of environmentally friendly technology, resource management, and community as well as government support.

Given this situation, the objective of this study was to analyze the impact of energy-based economic growth on CO_2 emissions within the framework of the environmental Kuznets curve (EKC) hypothesis in Indonesia. The novelty of this study was to analyze the quality of the Indonesian environment from the aspects of economic activity, energy use, government policies in the energy sector, and the scale population in the era of globalization.

2. LITERATURE REVIEW

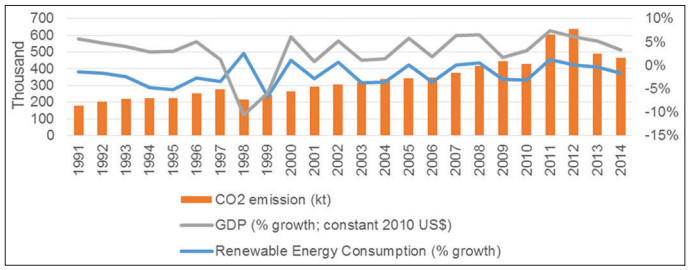
That accumulation of environmental damage during the process of economic development does not always increase, but at certain times, the economic development will cover the damage to the environment itself is a hypothesis, known as the EKC. EKC starts from Kuznets Curve analogy describing that in the process of economic development, there will be an inequality, but at one time, the economic development will reduce the gap (Vogel, 1999). The process by which an increase in national income is accompanied by an increase in environmental damage illustrates EKC, and then at a certain turning point, an increase in income will be followed by a decrease in the environmental damage (Grossman and Krueger, 1991; Shafik and Bandyopadhyay, 1992).

The EKC hypothesis could be applied to predict the impact of the economic development on the environmental status, and its results might be used as a consideration of how to overcome the impact. However, during the development process, as shown in Figure 2 of the EKC hypothesis, there were several points to consider. The points are, according to Andreoni and Levinson (2001), EKC hypothesis depends on (1) changes in the composition of production and consumption; (2) people's preference for environmental sustainability; (3) the role of related institutions that handle externalities of economic activities; and (4) the amount of return to scale providing for activities that harm the environment.

Some researchers carried out empirical studies of the EKC hypothesis on cases from many countries. Shahbaz et al. (2014), using a causality method and autoregressive distributed lag (ARDL) co-integration approach, proved that the EKC hypothesis is confirmed in Thailand. Furthermore, energy consumption and international trade openness increase pollutant emissions; while, urbanization of the population does not. Using the same approach, Ali et al. (2016) in Malaysia and Bölük and Mert (2014) in Turkey also confirm the EKC hypothesis.

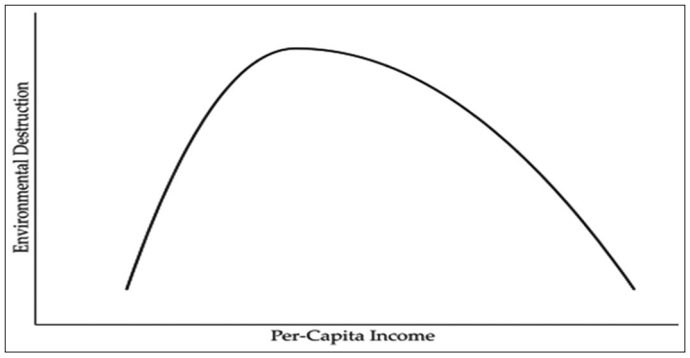
Meanwhile, Olale et al. (2018), using pooled effect (PEM) and fixed effect (FEM) models in the provinces and territories in Canada during 1990–2014, indicated that the two models showed different conclusions based on which PEM model confirmed EKC in some regions, based FEM models confirmed EKC in all regions of Canada. Those findings suggested that regional characteristics and technological innovations were the key to sustainable economic growth.

Figure 1: Economic Growth and Energy Development of Indonesia 1991–2014



Source: World Development Indicator (processed)

Figure 2: Environmental Kuznets curve (EKC)



Source: Uchiyama (2016)

Meanwhile, economic openness also had an impact on both economic growth and environmental sustainability. According to Dreher (2006), globalization that can increase economic growth is the one that put emphasizes on economic globalization rather than political globalization. However, although globalization promoted economic growth, it also increased CO_2 emissions, such as an empirical study in China. Ding et al. (2018) identified globalization causing the increase of CO_2 emissions, viewed from China's economic size both as the first largest exporting and as the second largest importing country in the world.

Several researchers in Indonesia also conducted research on EKC hypothesis[1]. Saboori and Soleymani (2012), using ARDL approach with samples from 1971 to 2007, found that the EKC hypothesis was not confirmed in Indonesia. In particular, research estimated CO_2 emissions to trade openness, energy consumption, and economic growth factors in root and square root. The findings based on U-shaped curve that the relationship between economic growth and CO_2 emissions exists means that in the short term, economic growth will reduce emissions, and then when it reaches the turning point, the increase in economic growth will increase CO_2 emissions.

1 Nugraha and Osman, 2019; Abidin et al., 2015; Nuryartono and Rifai, 2017; Islam et al., 2017; Bimanatya and Widodo, 2018; Yildirim et al., 2014; Al Mamun et al., 2014; Al-mulali et al., 2016 for the recent related literature.

Furthermore, Sugiawan and Managi (2016), also using ARDL approach with samples from 1971 to 2010, confirmed the existence of the EKC phenomenon in Indonesia. In contrast to the findings of Saboori and Soleymani (2012), Sugiawan and Managi (2016) criticized previous studies that did not include renewable energy factors in the model. Their findings indicated economic growth in the short term will increase CO_2 emissions; while, in the long run it will reduce CO_2 emissions. Renewable resources generated electricity proxy the role of renewable energy has an influence to reduce CO_2 emissions in both the short and long term. Furthermore, according to this study, turning point — economic growth will be accompanied by a reduction in CO_2 emissions — will be achieved when Indonesia's per capita GDP reaches 7729 USD, which has not been achieved.

3. RESEARCH METHODS

Primary energy is all energy resources - crude oil, coal, natural gas, biomass, and other energy sources such as water and geothermal energy - that can be extracted into other energy-derived products (Central Statistics Agency, 2017). This study investigated the influence of total energy consumption of the primary and renewable energy on the environmental conditions in Indonesia as well as confirmed whether the EKC hypothesis worked in Indonesia.

Technically, this research analyzed the effect of economic growth (EG), energy subsidies (ES), total use of primary energy (PE), renewable energy (RE), Economic Globalization (GE), and population growth (PG) on carbon dioxide emissions (CO_2). The study used secondary time series data from the World Development Indicator-World Bank, Central Statistics Agency (BPS), ETH Zurich, and Indonesian Ministry of Finance from 1990 to 2014.

In short, the operational description of variables is summarized in Table 1. Multiple regression models was used and was estimated using ordinary least square (Gujarati and Porter, 2009). The model of the econometric equation of this study is:

$$CO2_t=\gamma+\beta_1 EG_t+\beta_2 PE_t+\beta_3 ES_t+\beta_4 RE_t+\beta_5 PG_t+\beta_6 GE_t+\mu_t \quad (1)$$

Where γ is the constant, β is the coefficient of the independent variable, and μ is the error term.

Multiple linear regression analysis of this study was conducted using Eviews 6 software to identify the relationship between the independent variables (total primary energy, renewable energy use, energy subsidies, population growth, and globalization) and the total CO_2 emissions in Indonesia.

4. RESULTS AND DISCUSSION

4.1. Production and Consumption of Energy in Indonesia

The use of energy in Indonesia had not yet fully optimal to balance the production and the consumption. The demand of energy was mostly supplied and processed by Indonesia; yet, the most had been exported abroad. In fact, Indonesia's energy consumption growth is about twice that of production growth, and 96% of the energy is environmentally unfriendly (Mujiyanto and Tiess, 2013). Based on Figure 3, Indonesia's position is still a net exporter, and according to Indonesian Statistics Agency (2017), 64.8% of energy in Indonesia is exported raw. This state suggested that there were two obstacles at once; technology that was not well established yet to optimize energy production and the future negative impact of non-environmentally friendly energy used.

Figure 4 exhibits that energy production in Indonesia mostly comes from petroleum, coal, biomass, and gas. Over the past 4 years, petroleum as the largest supplier experienced a downward trend accompanied by an upward trend in supply of coal and biomass. Unfortunately, all of the energy sources are non-renewable energy; while, the renewable energy sources contributes only a small portion of energy supply in Indonesia (Mujiyanto and Tiess, 2013).

4.2. Empirical Results

The results of the estimation of the independent variables on carbon dioxide (CO_2) emissions are shown in Table 2.

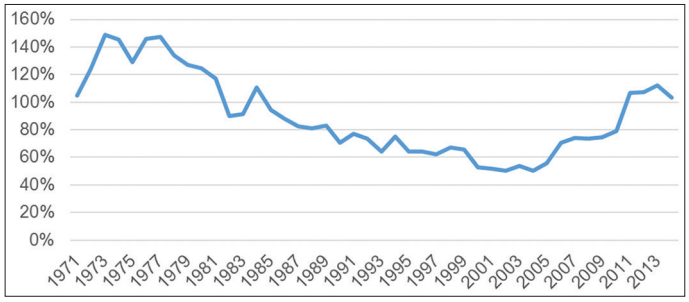
Table 2 reveals that the results of the estimation of multiple linear regression of the F-statistic are 161.0909 with a P = 0.0000. Thus, the variables of economic growth, total use of primary energy, energy subsidies, use of renewable energy, and population growth simultaneously affected carbon dioxide (CO_2) emissions. Meanwhile, as the value of the R-square is 0.981717, the economic growth, the use of primary energy, energy subsidies, the use of renewable energy, and population growth affected the variable of CO_2 emissions by 98.17%.

The estimation results of the multiple regression models shown in Table 2 means that the EKC hypothesis was not confirmed in Indonesia; therefore, the model described the relationship between the independent variables and the dependent variable in the long term. GDP as the main variable in the EKC postulate had a positive and significant direction on CO_2 emissions, as the economic growth (GDP) had an estimated coefficient of 0.0342 and a significant t-statistic value at $\alpha = 5\%$.

Table 1: Research variables

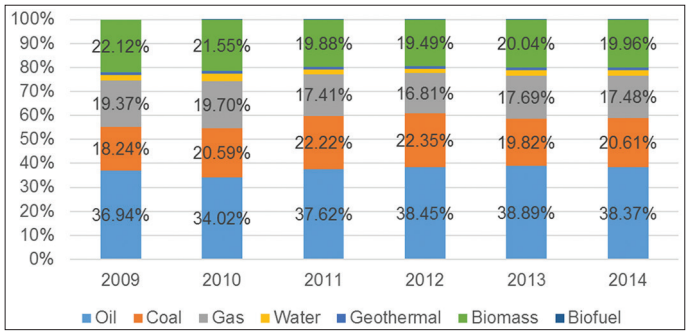
Variable	Symbol	Unit	Source
Total CO_2 emissions	CO_2	Kiloton	World Bank
GDP per capita	EG	US$ (constant 2010)	World Bank
Total use of primary energy	PE	Kg of oil equivalent per capita	World Bank
Total energy subsidy	ES	Billion Rupiah	Ministry of Finance of RI
Proportion of renewable energy use to total energy	RE	Percentage (%)	World bank
Economic globalization	GE	Index	ETH Zurich
Population growth	PG	Percentage (%)	CBS

Figure 3: Net export of Indonesia 1971–2014



Source: World Development Indicator-World Bank (2017)

Figure 4: Share of Indonesia Primary Energy Supply in 2009–2014



Source: Central Bureau of Statistics

On the other hand, as the Indonesian economy did not optimally support the environmental sustainability, the growth of the Indonesian economy tended to be accompanied by environmental degradation. Zoundi (2016) also identified similar results in the case of 25 countries in Africa that in the long term, the economic phases of these countries have not yet reached the turning point of the economic growth. In fact, economic growth will not automatically reduce carbon dioxide emissions (Özokcu and Özdemir, 2017).

In addition, the total use of the primary energy (PE) had a positive and significant effect on CO_2 emissions, as its estimated coefficient was 0.5261 and the t-statistic value was significant at $\alpha = 5\%$. This finding suggested that the increased use of the PE significantly increased CO_2 emissions. The results of this study were in line with the findings of Mujiyanto and Tiess (2013) that energy sources in Indonesia still depend on non-renewable resources, which is about 96% of the total energy used. Therefore, the negative impact of the PE used in Indonesia had a negative impact on the environment.

Meanwhile, energy subsidies (ES) positively but not significantly affected CO_2 emissions, meaning the increased subsidies potentially drove the CO_2 emissions. This finding was relevant to the one of Sasana et al. (2017) that subsidies have a positive and significant influence on CO_2 gas emissions. The results of the study proposed that subsidies could increase CO_2 emissions through the price of goods. When subsidized energy prices were increased, an individuals' real income would also increase, thus encouraged people to buy more fuel.

Further results indicated that population growth (PG) positively and significantly affected the increase of CO_2 emissions, which was proven by the coefficient of the population growth of 172.483 and

Table 2: Estimation results of the dependent variable of CO_2 emission

Variable	Coefficient	SE	t-Statistic	P
EG	0.034230	0.010345	3.308979	0.0039*
PE	0.526179	0.184683	2.849091	0.0107*
ES	−5.69E-06	8.05E-05	−0.070655	0.9445
PG	172.4833	69.48010	2.482485	0.0231*
RE	−5.219229	2.888065	−1.807172	0.0875**
GE	0.357793	0.800379	0.447030	0.6602
C	−162.9693	293.7275	−0.554832	0.5858
R-squared	0.981717			
Adjusted R-squared	0.975623			
F-statistic	161.0909			
Prob (F-statistic)	0.000000			

*Significance at $\alpha = 5\%$, **Significance at $\alpha = 10\%$

the t-statistic value significance at $\alpha = 5\%$. This finding suggested that the increasing population growth significantly increased CO_2 emissions. This finding was also in line with the one of Pata (2018) that population growth and mobility have a long-term positive relationship with CO_2 emissions. People had an important role in protecting the environment because they were the consumers of the energy themselves. Therefore, the increasing population growth would increase the level of consumption per capita and then led to the increasing emissions of carbon dioxide.

Meanwhile, the renewable energy (RE) negatively and significantly related to the amount of CO_2 emissions, as renewable energy (RE) had a coefficient of −5.2192 with a t-statistic value significance at $\alpha = 10\%$. This meant that an increase in the use of renewable energy would reduce CO_2 emissions significantly. The findings of this study were in line with the results of the study by Chen, et al. (2018) that the increasing use of renewable energy would reduce CO_2 emissions. Indonesia is a country with high-energy consumption, but due to lack of supporting infrastructure and raising investment in renewable energy, Indonesia still relies on oil as the main energy source (Kumar, 2015).

The last, economic globalization (GE) had a positive direction but did not significantly affect CO_2 emissions. This finding signposted that economic globalization in Indonesia was still at a safe level to maintain environmental sustainability. On the contrary, in the case in China, Ding et al. (2018) found that globalization significantly increases CO_2 emissions caused by the economic scale of China as the first largest exporting country and the second largest importing country in the world. Accordingly, from economic scale perspective, Indonesia has not fully had an important position in the global market.

5. CONCLUSIONS AND SUGGESTIONS

Based on the results of the research described earlier, the EKC hypothesis was not confirmed in Indonesia. Important points to be summarized are:

1. Indonesia still relies on environmentally unfriendly non-renewable energy sources to generate economy; consequently, in the long term GDP growth will be still accompanied by an increase in CO_2 emissions.
2. Energy subsidies are positively related but do not significantly

influence the increase or decrease of the amount of CO_2 emissions.
3. The use of primary energy increases CO_2 emissions; so, in the long term, Indonesia will still depends on primary energy sources.
4. The use of renewable energy sources will reduce the amount of CO_2 emissions; however, its implementation is still hampered by infrastructure and limited investment.
5. Increasing population will increase CO_2 emissions by increasing energy consumption per capita.
6. The level of economic openness does not significantly increase CO_2 emissions due to the scale of the Indonesian economy that is still not too large in the global market.

Keeping environmental sustainability must be done by every country by gradually changing the economic structure from business as usual concept to sustainable business-environment. Consequently, environmentally friendly processing technology factors including the increased use of renewable energy-based fuels must be implemented to minimize corrosive residues produced during the production process. This study proposes several points to support sustainable economy in Indonesia:

1. Increase the space for renewable energy sector by increasing awareness of environmental health and developing sustainable industries based renewable energy. The increase in flexibility will increase good socio-economic value (Kumar, 2015).
2. Controlling population growth rate to reduce energy consumption per capita; energy consumption in Indonesia is very large.
3. Increase the degree of economic openness by applying green economy indicators to support environmentally friendly economy.

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