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The Enviromental Kuznets Curve Hypothesis: an Empirical Evidence in Indonesia

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Abstract

The Environmental Kuznets Curve (EKC) hypothesis is the relationship between environmental and economic indicators forming an inverted U-curve. This paper aims to provide new insights using the long-term Vector Error Correction Model (VECM) technique. The research data use time series from 1974 to 2020. Empirical findings result in the formation of an open U-curve phenomenon. The immature post-industrialization stage in Indonesia hurts increasing CO2 emissions. Economic indicators as control variables that include population, consumption of electrical energy, and international trade ratios have a good impact on reducing CO2 emissions. The indicator of fossil energy consumption shows that Indonesia still has a dependence on non-renewable energy. After the ratification of the Kyoto Protocol in Indonesia, it does not have promising implications for reducing CO2 emissions. This paper provides important implications for establishing strict regulations to reduce CO2 emissions that contribute to climate change. In the future, the government must encourage people's behavior to save energy, optimize renewable energy, change energy demand patterns, transform low-carbon export products, and evaluate international agreements that impact the pattern of sustainable development in Indonesia.

Key words : EKC, VECM, Kyoto protocol, climate change, Sustainable development

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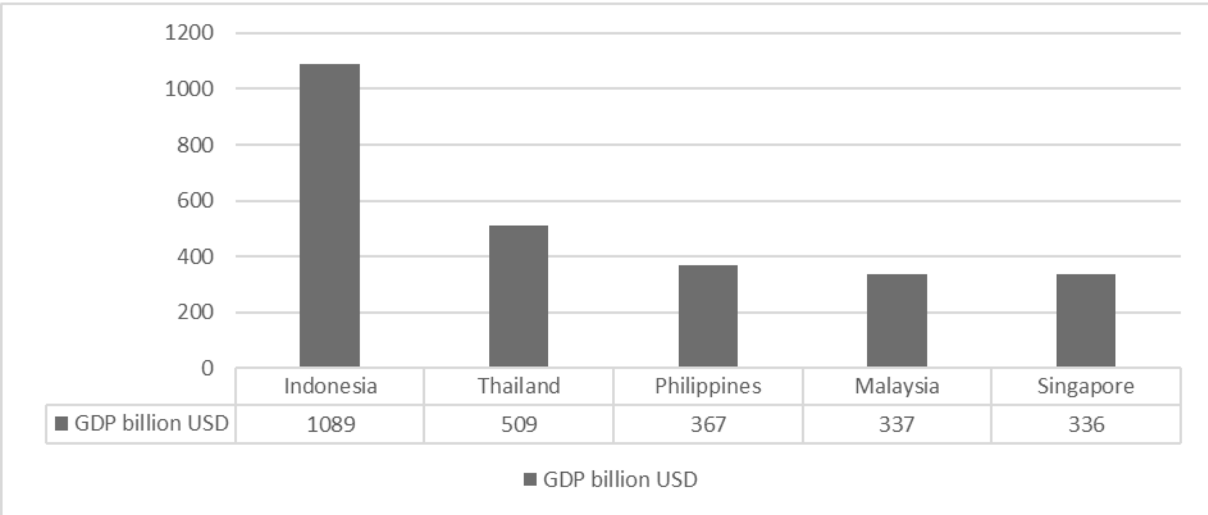
INTRODUCTION

The study of sustainable development economics has become exciting literature in this decade. The concept of a sustainable economy emphasizes optimizing limited resources to meet the present needs without compromising the needs of future generations (Polasky et al., 2019). Implementing a sustainable economy faces a trade-off between economic development and environmental quality (Kusumawardani, 2011). Economic development causes the deterioration of environmental quality due to the massive exploitation of natural resources (Chakravarty & Mandal, 2020). Economic activities that pursue economic growth targets will hurt the depletion of natural resources and environmental damage (Kurniawan & Managi, 2018).

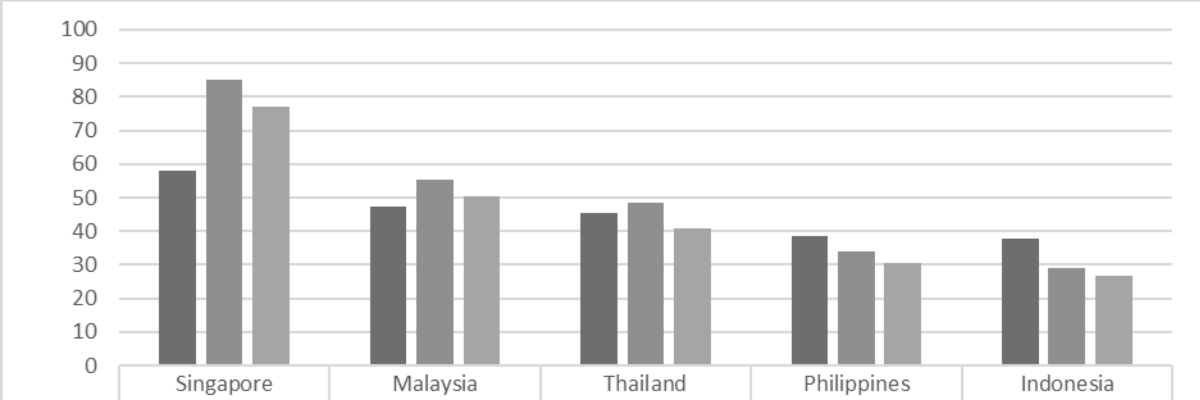
In developing countries, abundant natural resources are a source of greed to pursue short-term economic growth targets (Todaro & Smith, 2012). As a result of the destruction of nature, it has long-term adverse effects, according to Todaro & Smith (2012), causing increased health costs, decreased resource productivity, and climate change. Indonesia is a country with rapid economic development in the Southeast Asia region. The rapid economic growth in Indonesia is supported by increasing GDP productivity every year (Teguh & Bashir, 2019).



Source: International Monetary Fund (IMF)

Figure 1. ASEAN-5 GDP 2020 in Million USD

Indonesia is the country with the most significant economic volume in the Southeast Asia region, and the economy cannot be separated from the role of the industrial sector (Aswicahyono et al., 2010). Since the 1970s, the Orde Baru has implemented a policy of intensive industry and manufacturing to boost economic output (Retno, D., 2008). The government efforts in developing countries (including Indonesia) to objectively increase the volume of the economic impact of both unemployment and poverty, but environmental issues are not considered (Rashid Gill et al., 2018). The Environmental Performance Index report with index considerations, including the overall Environmental Performance Index (EPI), Environmental Health Score (EHS), and Air Quality (AQ), concludes that the government's role is weak in dealing with environmental problems.



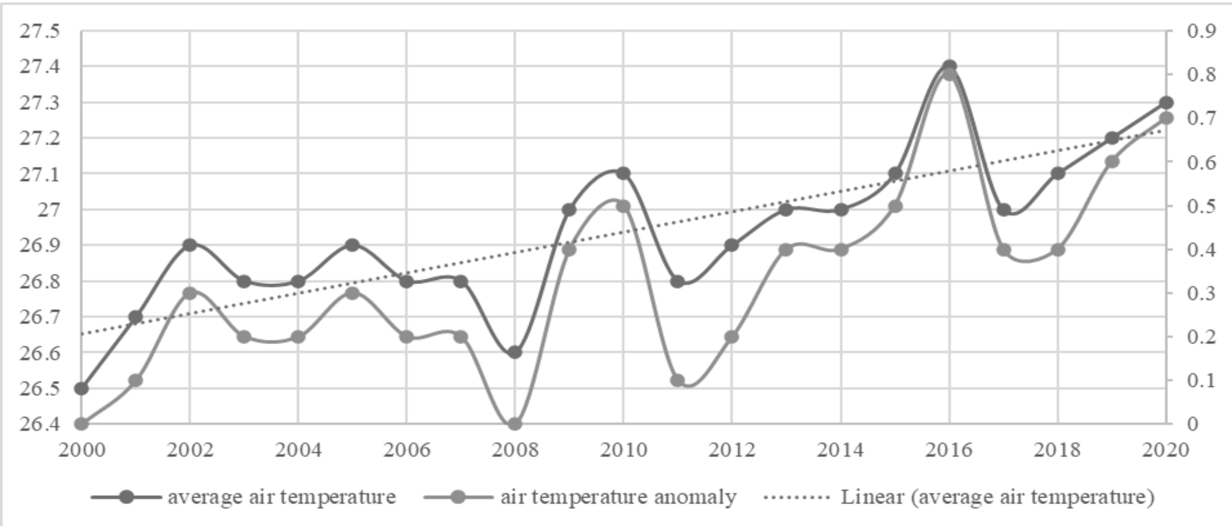
	Singapore	Malaysia	Thailand	Philippines	Indonesia
EPI	58.1	47.5	45.4	38.5	37.8
EHS	85	55.4	48.4	34.1	29
AQ	76.9	50.3	40.7	30.4	26.8

EPI EHS AQ

Source: EPI Report

Figure 2. Enviromental Performance Index (EPI) Report ASEAN-5 2020

Lin & Wang (2019), stated that deteriorating environmental quality in developing countries causes critical conditions for air pollution, depletion of natural resources, clean water crises, industrial waste, and human health impacts. The actual result of the deteriorating environmental quality in Indonesia is climate change. Climate change is a problem in development, not just an environmental issue (Ma & Jiang, 2019). Climate change can be observed by increasing the average air temperature due to greenhouse gas concentration. The Meteorology, Climatology, and Geophysics Agency of Indonesia recorded at 91 observation stations in Indonesia. It concluded that there had been an increase in the average air temperature in the last two decades. BMKG reports 2020 as the second hottest year in Indonesia, with an average air temperature of 27.3 degrees Celsius with an average air temperature anomaly reaching 0.8 points.



Source: BMKG

Figure 3. The Average Increase of Air Temperatur and Air Anomalies in Indonesia from 2000 to 2020

The literature on the Environmental Kuznets Curve (EKC) hypothesis is the link between the economic side and the environmental side. Initially, the EKC hypothesis was introduced by Grossman & Krueger (1991), using a panel approach in the case of NAFTA member countries. The study results show an inverted U-curve phenomenon in the relationship between GDP per capita (economic indicator) and environmental indicators. After the emergence of the EKC hypothesis, studies related to the EKC hypothesis have become interesting research materials. However, the consistency of the empirical analysis of the EKC hypothesis is doubtful (Nikensari et al., 2019).

In Indonesia, the literature on the EKC hypothesis is growing dynamically to prove its existence. The emergence of differences in the EKC discussion is the result of the analysis and the empirical method used. The study results by Muhammad Fajar & Hariyanto (2021), found empirical evidence of EKC with the Ordinary Least Square (OLS) regression approach. In contrast, the study by Saboori et al., (2012), rejected the EKC hypothesis with the Autoregressive Distributed Lag (ADRL) approach. There are inconsistent studies on the results and discussions by Sugiawan & Managi (2016), with the ADRL approach. This paper aims to prove the EKC hypothesis in Indonesia. The long-term Vector Error Correction Model (VECM) technique provided new insights into the Indonesian EKC literature that were not applied to previous studies.

The Environmental Kuznets Curve (EKC) hypothesis is an inverted U-shaped curve of the relationship between environmental degradation and economic indicators. The analogy of the EKC hypothesis states that when an economy takes off (followed by an increase in per capita income), it will cause environmental quality to deteriorate. However, when the per capita income level reaches a turning point, it will cause environmental quality to improve (Yang & Chng, 2019). The cause of the formation of an inverted U curve is due to the emergence of clean technology, strict environmental regulations, participation of people who care about the environment, and the changing nature of a pollutant over time (Grossman & Krueger, 1995). Another opinion by Theodore Panayotou (2003), states that the economy's structure controls the bending of the curve. The post-industrial economy has a positive impact on the environment.

The EKC literature is a hot topic of discussion (Xu et al., 2021). In Indonesia, the investigation of the EKC hypothesis gave different results (Setyadharma et al., 2020). Previous studies using various analytical methods provide multiple conclusions. Chen & Taylor (2020), opened a new chapter of the EKC hypothesis research using the VECM long-term balance technique in a study in Singapore. We summarize the previous studies conducted in Indonesia as exciting discussion material and offer an update on the paper that we present.

A study by Adebayo (2021), using the ADRL approach from 1980 to 2016 provides evidence of an inverted U-curve. The study by Muhammad Fajar & Hariyanto (2021), using the OLS regression approach from 1960 to 2016 supports the EKC hypothesis phenomenon in Indonesia. A study by Setyadharma et al., (2020), used a panel approach in 33 provinces in Indonesia from 2012 to 2018. Environmental indicators using the environmental quality index show an inverted U-curve phenomenon. We also found some ambiguous research on the results of the discussion. The study by Sugiawan & Managi (2016), using ADRL for the period 1971 to 2010 gave the results of an inverse U relationship on behavior between variables, but it was not significant. The discussion results were increasingly ambiguous because the researcher provided a turning point estimate. Then, the study by Darwanto et al., (2019), using ADRL-based Granger Causality in the period 1990 to 2016 gave similar results: a behavioral relationship between variables formed an insignificant inverted U-shape.

The EKC hypothesis could not be proven empirically in the study of Saboori et al., (2012), used ADRL from 1971 to 2007; the results showed an open U-curve. Unfortunately, no explanation supports the formation of the open U-curve phenomenon. A study by Sumargo & Fadlilah (2019), using the Error Correction Mechanism (ECM) from 1965 to 2014 rejected the EKC hypothesis in Indonesia. A study by Noor & Putu Mahardika Adi Saputra (2020), using OLS regression from 1971 to 2014 concluded that the EKC hypothesis does not apply in Indonesia.

We offer a new study investigating the Indonesian EKC hypothesis of forming an open U-curve. First, we used the VECM long-term balancing technique not applied in previous studies. Second, the study by Saboori et al., (2012), did not conclude the formation of an open U curve on the EKC hypothesis. Third, we provide a dummy variable for the Kyoto Protocol as a mitigation measure for climate change problems. We offer a new perspective on the ineffectiveness of the Kyoto Protocol based on empirical evidence.

Therefore, the hypothesis in this research are: Ha1: there is an influence between GDP per capita towards CO_2 emissions per capita; Ha2: there is an influence between quadratic GDP per capita towards CO_2 emissions per capita; Ha3: there is an influence between population towards CO_2 emissions per capita; Ha4: there is an influence between electricity consumption per capita towards CO_2 emissions per capita; Ha5: there is an influence between total consumption of fossil energy towards CO_2 emissions per capita; Ha6: there is an influence between international trade ratio towards CO_2 emissions per capita; Ha7: there is an influence before and after of Tokyo Protocol towards CO_2 emissions per capita.

METHOD

The construction of an econometric model to test the EKC hypothesis on the relationship between CO_2 carbon emissions and development indicators. CO_2 emissions are used as an indicator of environmental degradation because 75% of the contribution the greenhouse gases is by carbon dioxide (Widyawati et al., 2021). The formulation of the econometric model is constructed by:

$$COCAPt = f(YCAPt, YCAP2t, POPt, ELCt, FOSSILt, KPt) \quad (1)$$

The VECM long-run equilibrium estimation model, according to Chen & Taylor (2020), is formulated as follows:

$$ECTt = COCAPt - \beta 1YCAPt - \beta 2YCAP2t - \beta 3POPt - \beta 4ELCt - \beta 5FOSSILt - \beta 6TRADEt - ØKPt - \alpha o \quad (2)$$

Where, COCAP= CO_2 emissions per capita (metric tons per capita), YCAP= GDP per capita (USD), YCAP2 = quadratic per capita income, POP = population (people), ELC= electricity consumption per capita (KWh), FOSSIL= total consumption of fossil energy (%), TRADE= international trade ratio (% GDP), KP= Kyoto Protocol; dummy variable. ECT= error correction term, 1-6= long-term regression coefficient, = matrix coefficient associated with the dummy variable, and o = constant term.

The research period is from 1974 to 2020, using the long-term Vector Error Correction Model (VECM) technique. Stages of estimation through four steps (Chen & Taylor, 2020). The first stage is the unit root test of the research variables. Data that is not stationary will cause a spurious regression problem (Gujarati & Porter, 2009). If the data is stationary at the level, then the estimation uses Vector Autoregressive (VAR), but it is stationary at first different; it is estimated using VECM. The Dickey-Fuller GLS test was used to test the unit root.

Table 1. Descriptive Time-series Variable

Variable	Abbreviation	Data Range	Source
CO_2 per capita (metric ton)	COCAP	1974-2020	World Bank
Gross domestic product per capita (USD)	YCAP	1974-2020	World Bank
Gross domestic product per capita^2	YCAP2	1974-2020	-
Population (person)	POP	1974-2020	World Bank
Electricity consumption per capita (KWh)	ELC	1974-2020	World Bank
Total fossil consumption (% of total)	FOSSIL	1974-2020	World Bank
Trade Openness (% GDP)	TRADE	1974-2020	World Bank
Kyoto Protocol	KP	1974-2020	-

Note: KP = Kyoto Protocol is a dummy variable of the global agreement to reduce carbon emissions. It was formed in 1997 and legalized in 2005. KP = 0 for 1974-2004, KP = 1 for 2005-2020.

The second step is the cointegration test, and the constructed model must have a long-term relationship. The VECM procedure requires that it is stationary at first different and has cointegration (Sinay, 2014). Optimal lag is needed to test cointegration by comparing the Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) values. After the optimal lag is obtained, the cointegration test is continued by comparing the Max Eigen Test and the Trace Statistics Test. The error correction can be represented if the two tests show a long-term relationship equation at the 5% significance level (Andrei & Andrei, 2015).

The third step is to estimate the constructed model. If t-statistics > t-table, then the relationship between variables is significant. Then the last step is the diagnostic test. The model that is built must be feasible and can be interpreted. The long-term dynamic model diagnostic test should be free from autocorrelation and heteroscedasticity problems (Chen & Taylor, 2020; & Gujarati & Porter, 2009). The autocorrelation test used the Breusch-Godfrey Serial Correlation, while the heteroscedasticity test used ARCH. The model is free from the classical assumption problem if the probability value is > 5% significance level.

RESULTS AND DISCUSSION

Data must have a stationary assumption the mean and variance do not vary systematically over time (Gujarati & Porter, 2009). Data that is not stationary will cause spurious regression problems (Andrei & Andrei, 2015). The spurious regression problem causes the regression results to have no economic meaning or cannot be represented. VECM has the assumption that the data (research variables) must be stationary in the first difference. We used the Dickey-Fuller GLS for the unit root test conclusions were drawn if the t-statistic of Dickey-Fuller GLS > the critical value of 5%. Based on table 2, the research variables are stationary at first different.

Table 2. GLS Dickey-Fuller Test for Unit Roots

Variable	T-Statistic At Level	T-Statistic At First-Different	Critical Value At 5%
COCAP	-2.858.787	-6.128311	-3.190000
YCAP	-1.551.399	-4.751151	-3.190000
YCAP2	-1.722.045	-4.160530	-3.190000

Variable	T-Statistic At Level	T-Statistic At First-Different	Critical Value At 5%
POP	-0.418400	-3.966.067	-3.190000
ELC	-1.544.935	-3.351282	-3.190000
FOSSIL	-1.940.320	-6.443.112	-3.190000
TRADE	-3.129.466	-9.940500	-3.190000

Note: If the t-statistic < critical value 5%, then Ho is rejected, and the variable does not have a unit root (stationary).

Lag Length Criteria to determine the optimal lag length of the built model. The specified lag length must be precise. A too-short lag will cause the actual error not to be estimated correctly, while a too-long lag will reduce the degrees of freedom (Gujarati & Porter, 2009). We compare the lowest values of AIC and SC to determine the optimum lag. Table 3 shows that the AIC value is lowest at the third lag.

Table 3. Lag Length Criteria

Lag	LR	FPE	AIC	SC	HQ
0	305.552	7.70e+2	86.914	87.241	87.035
1	133.621	1.99e+2	80.904	83.853*	81.991
2	133.621	3.13e+2	78.741	84.311	80.795
3	89.092*	1.14e+2*	76.768*	84.960	79.789*

Note: AIC has a minimum value compared to SC. The e-views recommend optimum lag at the third lag. LR, FPE, AIC, HQ are on 3rd lag.

The model built must have a long-term relationship to test the cointegration using Johansen Cointegration. The long-term relationship of the constructed model is determined from the Max Eigenvalue and Trace Statistics > 5% critical value. The results of table 4 show that the model has five long-term equations.

Table 4. Johansen Cointegration

Trace Statistic	Critical value	Max Eigen	Critical value
284.7860*	125.6154	99.55545*	46.23142
185.2305*	95.75366	68.72920*	40.07757
116.5013*	69.81889	55.58206*	33.87687
60.91925*	47.85613	33.16188*	27.58434
27.75737*	29.79707	13.91710*	21.13162
13.84027	15.49471	10.83945	14.26460
3.000816	3.841466	3.000816	3.841466

Note: • Trace Statistics > 5% critical value, there are 5 cointegration equation relationships. Max Eigen > 5% critical value, there are 5 cointegration equation relationships.

The VECM procedure can be used in this paper, considering the stationary research variables on the first difference, and the model has cointegration equations. The results of the long-term VECM equilibrium regression output are in table 5. In the last step, the autocorrelation and heteroscedasticity diagnostic tests did not show the classical assumption problem (p > 0.05).

Table 5. Output VECM Long-run Balance

Variable	Coefficient	T-statistic	Ect
COCAP	1		-2.47210
YCAP	-0.001693	-20.8759	-0.26115
YCAP2	2.58E-07	16.1987	-0.10390
POP	-1.66E-08	-9.79119	4.74691
ELC	-0.001523	-8.58449	-2.93060
FOSSIL	0.072271	17.3753	-1.37824
TRADE	-0.029345	-16.1394	2.36120
KP	1.171070	21.8302	-0.42401
C	-0.164602		

Note: • Significant 5%, t-statistic < t-table then Ho is rejected.

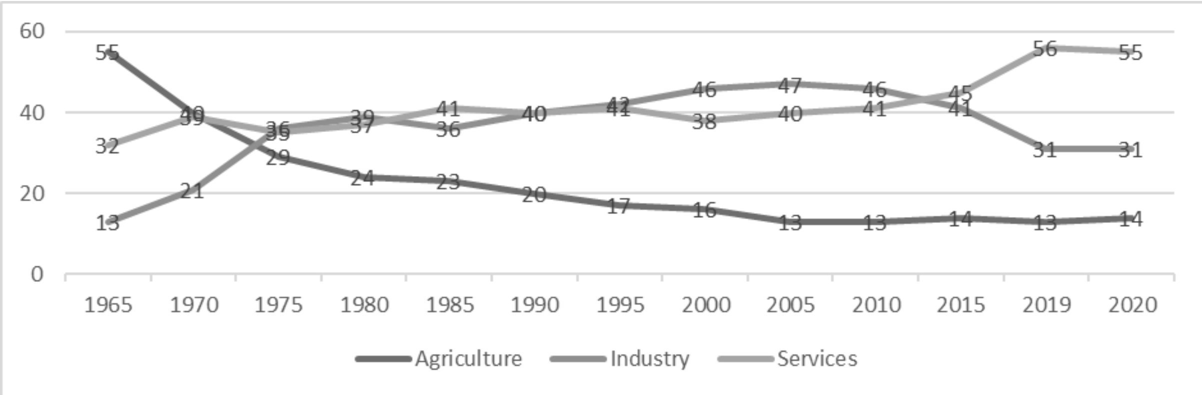
Table 6. Diagnostic Test

Prob. Breusch-Godfrey Serial Correlation	Prob. ARCH Heteroscedasticity
0.4751	0.8832

Note: • Probability of diagnostic test < critical value 5%, reject Ho

All t-statistics of variables in the long term were significant at 5% significance level (Table 5). The negative YCAP coefficient is significant in long-term equilibrium (β1 = -0.001693), and the positive YCAP2 coefficient is significant in long-term equilibrium (β2 = 2.58 x 10-7). The EKC hypothesis indicates the formation of an open U curve in the case of Indonesia. Accordingly, increasing per capita income by 1 USD will reduce CO_2 emissions by 0.001693 metric tons per capita.

The investigation of the EKC hypothesis by Saboori et al. (2012) found the formation of an open U curve in long-term equilibrium with the ADRL method. Unfortunately, there is no further confirmation regarding the cause of the appearance of the open U-curve. We find that industrial sectors are responsible for increasing CO_2 emissions in Indonesia. The Ministry of Energy and Mineral Resources of the Republic of Indonesia, in its latest report, states that the energy-producing industrial sector generates 43.83% of emissions, the transportation sector generates 24.64%, and 21.46% is generated by the manufacturing industry sector (Sunarti et al., 2020). Then, we find evidence that Theodore Panayotou (2003), argument has not been able to be applied to cases in Indonesia. Indonesia has entered the post-industrial stage. The service sector controls the total composition of GDP. In the early stages, the economy depended on the agricultural sector. Increased resource extraction will encourage industrialization to take off. In the next step, the industrial sector takes control of the economy's output. The increase in the industrial sector has led to an increase in cases of environmental damage. At the turning point, the post-industrial economy was controlled by the service sector, which relied on the efficiency of information and technology. The increase in the service sector results in a leveling-off process and reduces cases of environmental degradation.



Source: World Bank

Figure 4. Structural Transformation of the Indonesian Economy (% GDP)

According to Theodore, P. (2003), framework, Indonesia should have reached a turning point for the EKC hypothesis. In 2010, Indonesia experienced a condition of deindustrialization, which caused the service sector to play a strategic role in economic output (Sholihah et al., 2017). We argue that Indonesia is experiencing an immature phase of industrialization. The characteristic of the deindustrialization phase is that the post-industrial stage (service economy) cannot reduce the effects of environmental degradation and low per capita income. The imperfect transition from the industrial economy stage to the post-industrial economy results in a demand for resources that is still intensive and the, resulting in high carbon emissions (Iskandar, 2019).

The significant negative coefficient of POP (-1.66E-08) in the long-term results in the finding that an increase in the number of people by one person will reduce emissions by 1.66 x 10-8 metric tons per capita. Indonesia's population pyramid structure is dominated by children aged (0-14 years) and old age (> 64 years), which has a good impact on the CO_2 activity produced (Nurrahmawati & Kusumawardani, 2021). Indonesia is predicted to be independent of the population dependency ratio in 2030 (Warsito, 2019). The Indonesian government must anticipate the negative impact of the increasing population and working age in the future by encouraging people to care about the environment.

The long-term finding of the ELC variable shows a significant negative coefficient (-0.001523). Thus, increasing 1 KWh per capita electricity consumption will reduce CO_2 emissions by 0.001523 metric tons per capita. The contribution of renewable energy to the electrical energy mix in Indonesia can reduce the emissions produced (Rokhmawati, 2020). The latest report managed by the Ministry of Energy and Mineral Resources of Indonesia claims to have succeeded in reducing emissions resulting from electricity consumption in 2020 to reach 64.35 million tons of CO_2.

The significant positive coefficient of FOSSIL (0.072271) in the long-term results in the finding that increasing fossil energy consumption by 1% will increase CO_2 emissions by 0.072271 metric tons per capita. Indonesia still relies on fossil energy sources in its economic activities (Darwanto et al. 2019). Energy diversification in Indonesia is not practical. The government's behavior in providing fossil fuel subsidies hurts increasing CO_2 emissions, increasing demand for fossil energy, and budget deficits (Ermawati, 2015).

The international trade ratio has a significant negative coefficient (-0.029345). Thus, increasing the trade ratio by 1% of GDP will reduce CO_2 emissions by 0.029345 metric tons per capita. The primary sector dominates Indonesia's trade specialization (Widyawati et al., 2021). The Indonesian government's policy to limit coal production to 400 million tons per year can reduce the CO2 emissions produced.

The estimation result of KP or the Kyoto Protocol dummy variable has a significant positive coefficient (1.171070). The Kyoto Protocol does not effectively control the CO2 emissions produced. The Indonesian government has a low commitment due to the high cost of reducing emissions. The Kyoto Protocol is irrelevant because the emission reduction target is not ideal between countries (Pratama, 2020). The implications and application of the Kyoto Protocol in Indonesia are not implemented optimally (Fattah, 2013). Climate Transparency Society (2020), report places the commitment of the Indonesian government as a "highly insufficient" country in tackling climate change.

CONCLUSION

This paper comprehensively discusses the effect of CO2 emissions per capita on economic indicators covering per capita income, population, electricity consumption per capita, fossil energy consumption, international trade ratios, and the Kyoto Protocol as a framework for international agreements to reduce emissions. Empirical evidence of the EKC hypothesis shows an open U-curve. The industrialization phase in Indonesia is not mature enough to encourage increased CO2 emissions produced. This paper suggests that policymakers in Indonesia strengthen regulations related to the environment and the impact of climate change. Then, we suggest that the Indonesian government encourage people to use energy wisely. Optimizing and changing the pattern of energy demand will reduce the CO2 emissions produced. In international trade activities, the Indonesian government must encourage the creation of low-carbon export products.

To find better future findings related to the EKC hypothesis, the relationship between environmental indicators and economic indicators. Future research can consider three crucial points. First, indicators of environmental degradation do not only use CO2. Indicators of carbon monoxide (CO), sulfur monoxide (SOx), and nitrogen dioxide (NOx) have negative externalities on the environment and human health (Chen et al., 2007). Second, the dynamic regression model has a sensitivity to lag. Different lags will affect the regression results, causing decision-making bias (Setyadharma et al., 2020). Third, a panel study by Akan & Balin (2015), considers innovation and technology factors in EKC modeling. One of the causes of the bending of the EKC curve is the development of environmentally friendly technologies (Grossman & Krueger, 1995). For further research, it much better if we examine more institutional variables. Future research could focus on political and institutional variables due to the less effectively of Kyoto Protocol to tackle the emissions.

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