Avalaible online at http://journals.ums.ac.id, Permalink/DOI: 10.23917/jep.v24i1.23191

Jurnal Ekonomi Pembangunan: Kajian Masalah Ekonomi dan Pembangunan, 24 (2), 2023, 320-330

Testing the Environmental Kuznets Curve (EKC) Hypothesis in Indonesia and India: Autoregressive Distributed Lag (ARDL) Model Approach

Indanazulfa Qurrota A'yun[1], Muhammad Safar Nasir[2], Zarul Azhar bin Nasir[3], Fatima Muhammad Abdulkarim[4], Murtaza Hussain[5]

[1]Faculty of Economics and Business, Universitas Ahmad Dahlan, Indonesia
[2]Department of Economics and Financial Studies, Universiti Teknologi MARA (UiTM), Malaysia
[3]Faculty of Economics and Business, Universitas Ahmad Dahlan, Indonesia
[4]Faculty of Management and Social Sciences, Federal University Dutse, Jigawa State, Nigeria
[5]School of Economics and Finance, Xi'an Jiaotong University, China
Corresponding Author: indanazulfa.ayun@ep.uad.ac.id

Received: June 2023 | Revised: December 2023 | Accepted: December 2023

Abstract

The achievement of economic growth is equally important as environmental sustainability. Economic growth is considered capable of enhancing the overall welfare of society. However, there is a sacrifice stemming from economic growth in the form of negative external impacts. Therefore, the objective of this study is to examine the Environmental Kuznets Curve (EKC) hypothesis in Indonesia and India. The EKC hypothesis connects economic growth with CO2 emissions. The Autoregressive Distributed Lag (ARDL) model is employed to assess both the long-term and short-term impacts of economic growth on CO2 emissions in Indonesia and India. Additionally, the study seeks to comprehend the applicability of the Environmental Kuznets Curve (EKC) hypothesis in these countries over the period of 1965-2021. The research findings indicate that economic growth has a significant impact on CO2 emissions in the short term, but this influence is not sustained in the long term in Indonesia. In contrast, in India, economic growth does not exhibit a significant effect on CO2 emissions in the short term, but it does have a notable impact in the long term. This implies that Indonesia does not align with the Environmental Kuznets Curve (EKC) hypothesis in the long term, while India is anticipated to adhere to the EKC hypothesis in the future.

Keywords: ARDLM, EKC, Emission CO2, Environment
JEL classification: 044, Q56, R11

How to Cite: A'yun I. Q., Nasir M. S., Nasir Z. A. B., Abdulkarim F. M., Hussain M. (2023). Testing the Environmental Kuznets Curve (EKC) Hypothesis in Indonesia and India: Autoregressive Distributed Lag (ARDL) Model Approach, 24(2), 320-330. doi:https://doi.org/10.23917/jep.v24i1.23191

DOI: https://doi.org/10.23917/jep.v24i2.23191

1. INTRODUCTION

Economic growth is the target of development goals for all countries. Economic growth is considered capable of increasing the welfare of society in general. However, on the other hand there is a tradeoff caused by economic growth itself, namely in the form of negative externalities. One form of negative externality that occurs is climate change. According to the World Economic Forum (WEF), climate change is the most serious problem that can affect the world (WEF, 2017). Climate change is a consequence of economic activities in each country that produce carbon emissions (Tol, 2012; Nikensari, 2017; Bekun et al, 2019; Song, 2021). The increasing impact of carbon dioxide (CO2) emissions and climate change on the economy has been studied extensively, to reduce the level of carbon dioxide emissions is to adopt climate change mitigation in the environment (Cahyadin et al., 2021).This aligns with the explanation provided by Chen et al. (2022) that the primary drivers of global climate change stem from the heightened utilization of fossil fuel energy and the economic growth witnessed over the past century. Landrigan (2017) explained that there is a negative impact of carbon emissions for the human health. In addition, as a result of low environmental quality, it will also have an impact on decreasing happiness (Goetzke et al, 2015), decreasing the subjective health and welfare of the community (Zhang et al, 2017).

Attaining a certain level of economic growth is deemed equally crucial to ensuring environmental sustainability. In a review of relevant literature, The Environmental Kuznets Curve (EKC) hypothesis suggests that economic growth, initially linked to environmental degradation, is followed by a phase of environmental improvement. This hypothesis presents a compelling research topic, particularly given the escalating global concerns regarding environmental degradation. It is particularly pertinent for developing nations, as policymakers grapple with the imperative to achieve the optimal equilibrium between fostering economic growth and maintaining ecological integrity.

Figure 1 and 2 explain that the number of gdp per capita for Indonesia and India has continued to increase from 2010-2018. India has a higher GDP per capita than Indonesia. However, as displayed in Figure 2, the amount of CO2 emissions produced by Indonesia is greater than that of India.

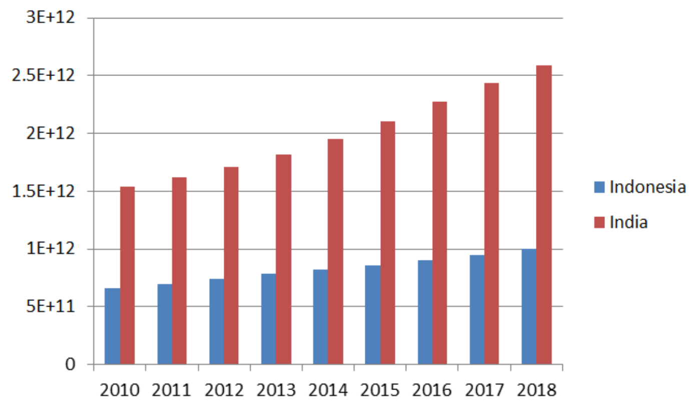

Figure 1. Total GDP per capita of Indonesia and India in 2010-2018

Source: World Bank (2022)

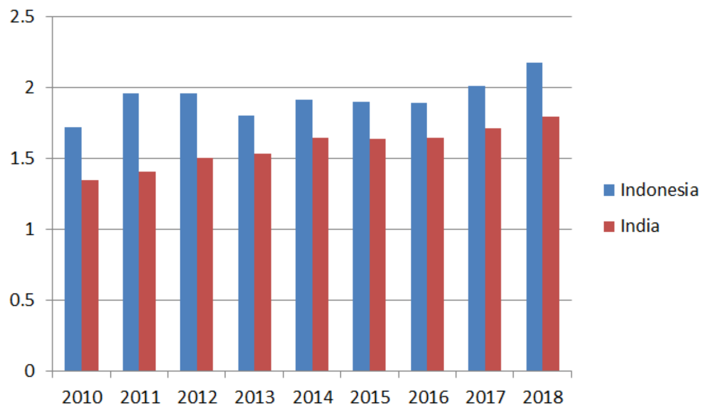

Figure 2. Total CO2 Emissions from Indonesia and India in 2010-2018

Source: World Bank (2022)

Avalaible online at http://journals.ums.ac.id, Permalink/DOI: 10.23917/jep.v24i1.23191

Jurnal Ekonomi Pembangunan: Kajian Masalah Ekonomi dan Pembangunan, 24 (2), 2023, 320-330

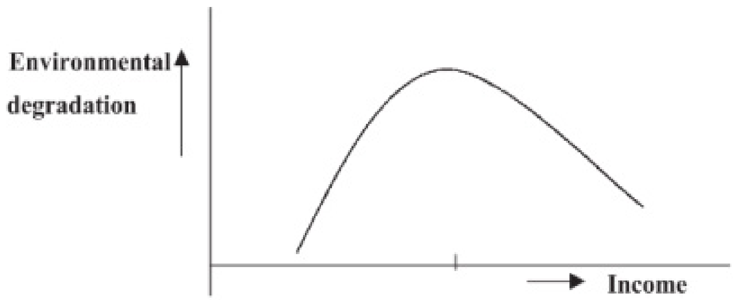

Figure 3. The Hypothesis of Environmental Kuznets Curve (EKC)
Source: Grossman and Krueger (1995)

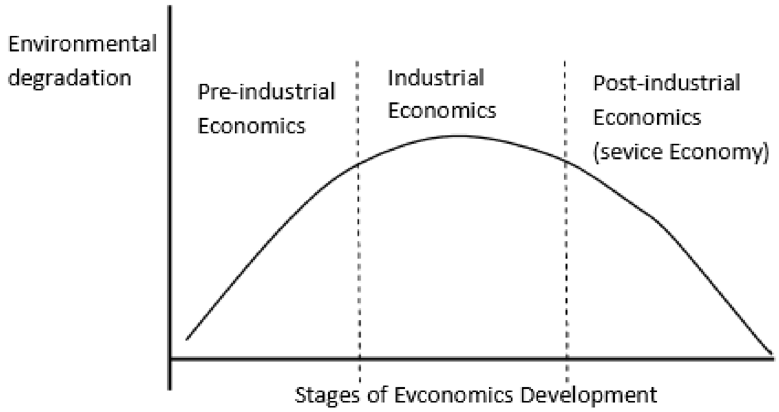

Figure 4. Stages of Environmental Degradation and Economic Development
Source: Grossman and Krueger (1995)

Improving quality and environmental sustainability is the main discussion at this time. However, increasing economic growth is also important, especially for developing countries. Therefore, the analysis of testing the EKC hypothesis is important to do in Indonesia and India.

EKC hypothesis indicates a positive correlation within the short term regarding the relationship between economic growth and environmental degradation. However, upon reaching a higher income level, economic growth is anticipated to mitigate environmental degradation within a country. Figure 3 depicts the inception of the EKC hypothesis, signifying a progression from the Kuznets theory formulated by Grossman and Krueger (1995), outlining the structure of an inverted U-curve.

In theory, it is suggested that developing nations, particularly those with lower per capita income, tend to experience environmental degradation (Spilker et al., 2017). This is attributed to the early stages of industrialization in these countries, where the primary focus is on economic advancement and job creation, often overlooking environmental concerns. Consequently, During this developmental period, there is a positive correlation between economic growth and changes in environmental conditions. Nevertheless, as these countries attain economic milestones and witness with an increase in per capita income, there is a growing awareness of environmental issues. This transition is depicted in Figure 4 through the Environmental Kuznets Curve. During this stage, individuals begin to demonstrate a willingness to forego some consumption for the greater cause of environmental preservation (Tenaw et al., 2021).

The hypothesis of Environmental Kuznets Curve (EKC) serves as a dominant theoretical framework linking the impacts of economic growth to environmental consequences. Shahbaz and Sinha (2019) and Purcel (2020) provide comprehensive reviews of the EKC hypothesis in their comprehensive literature reviews. Kilavus and Dogan (2020) also conduct empirical research focusing on the relationship between economic growth, trade liberalization, and industrial activities on emissions of CO2 from 1961 to 2018 in Turkey. Their findings indicate a positive connection between industrial activities and the economic growth leading to rise a CO2 emissions, while economic openness shows insignificant effect on CO2 emissions.

The role of economic openness is pivotal in supporting foreign trade for developing nations (Karedla et al., 2021). Although economic openness contributes to increased domestic and industrial production, it is linked to heightened pollution (Jun et al., 2020). This aligns with research across various countries, suggesting that pollution levels tend to increase with heightened trade openness (Lin, 2017; Wen et al., 2020). However, conflicting perspectives exist, with some studies proposing that economic openness may reduce pollution levels (Shahbas et al., 2017; Ghazouani et al., 2020). Wang and Zhang (2021) observe that economic openness has a positive effect on pollution in low-income countries and a negative effect in high or middle-income countries.

There is a notable and statistically significant positive relationship between economic growth and energy consumption. (Esen and Bayrak, 2017). Consequently, heightened energy use often results in increased CO2 emissions, contributing to environmental degradation. Many studies confirm a positive connection between economic growth and pollution (Lin et al., 2014; Alshehry and Belloumi, 2015; Canh et al., 2019; Zafar et al., 2020; Song, 2021).

Limited studies have specifically tested the hypothesis of Environmental Kuznets Curve (EKC) in developing countries. Typically, these studies employ a single-variable approach and aim solely to observe effects. Therefore, this research distinguishes itself by aiming to test the EKC hypothesis specifically in Indonesia and India. This involves not only examining its effects but also substantiating whether the EKC theory and hypothesis are applicable in the contexts of Indonesia and India. The study additionally comparing environmental quality in both countries over the short and long term, utilizing the autoregressive distributive lag (ARDL) approach.

2. RESEARCH METHOD

In examining the Environmental Kuznets Curve (EKC) Hypothesis in Indonesia and India, The Autoregressive Distributed Lag (ARDL) model emerges as a robust and informative analytical method. This modeling technique is well-suited for capturing dynamic relationships in time series data, Understanding the complex interplay between economic development and environmental quality is crucial, which is evident. The flexibility of ARDL in handling both stable and unstable variables is useful for studying the changing statistical properties of environmental and economic indicators over time. By incorporating lagged differences and an error correction mechanism, the ARDL model allows for in-depth exploration of short-term dynamics and long-term equilibrium relationships, enhancing understanding the context of EKC Hypothesis. In this study exploring the economic-environmental dynamics of two different countries, Indonesia and India, the ARDL model emerges as a reliable and widely accepted tool to provide insights into the intricate relationship between environmental sustainability and economic growth.

This research uses time series data from 1965-2021 in Indonesia and India. CO2 emissions per capita in kt is the dependent variable employed in this study. The CO2 emission variable is influenced by both GDP Per Capita and GDP Per Capita Square, creating a quadratic relationship. If GDP per capita has a significant positive impact while GDP per capita squared has a significant negative impact, it means that the Environmental Kuznets Curve (EKC) hypothesis can be substantiated.

Furthermore, this study incorporates several other independent variables, namely energy consumption (EC) measured in kilograms of oil equivalent per capita, and trade balance (TB) representing the difference between exports and imports in $US as an indicator of trade openness. All the data utilized in this study are secondary data obtained from the World Bank Development Indicator (WDI) and Our World in Data.

The Autoregressive Distributed Lag (ARDL) model employed in this research was developed by Pesaran & Shin (1997). The model is utilized to analyze the long and short-term relationships among CO2 emissions, GDP per capita, energy consumption, and trade balance.

$$CO2 = f(GDP, GDP^2, EC, TB) \quad [1]$$

The approach of ARDL is used to ascertain the cointegration status of all variables. In general the form is would be:

$$CO_{2t} = \propto_0 + \propto_1 GDP_t + \propto_2 GDP_t^2 + \propto_3 EC_t + \propto_4 TB_t + \varepsilon_t \quad [2]$$

$$CO_{2t} = \propto_0 + \propto_1 GDP_t + \propto_2 GDP_t^2 + \propto_3 EC_t + \propto_4 TB_t + \varepsilon_t \quad [3]$$

Equation 2 is for Indonesia's country equation and equation 3 is for India's equation. Then, in analyzing time series data is to do a stationary test. The test can be applied by the Philips Perron as a unit root test, and the model as follows:

$$\Delta Y_t = \gamma Y_{t-1} + \textstyle\sum_{i-2}^{\rho} \beta_i \Delta Y_{t-i+1} + e_t \quad [4]$$

$$\Delta Y_t = \alpha_0 + \gamma Y_{t-1} + \textstyle\sum_{i-2}^{\rho} \beta_i \Delta Y_{t-i+1} + e_t \quad [5]$$

$$\Delta Y_t = \alpha_0 + \alpha_1 T + \gamma Y_{t-1} + \textstyle\sum_{i-2}^{\rho} \beta_i \Delta Y_{t-i+1} + e_t \quad [6]$$

Where Y is the observed variable and T shows the time trend. To determine whether the data is stationary or not is to compare the PP statistical value with the critical value of the t statistical distribution.

Determination of the optimum lag in the ARDL model aims to determine the combination of ARDL model lags (p,q) so that in the ARDL model each variable will have a different lag. The optimum lag is chosen based on the base value approach of Akaike Information Criterion (AIC). Furthermore, the lag consistency in the approach of Akaike Information Criterion (AIC) can be written as follows:

$$-2\left(\frac{l}{T}\right) + \frac{2k}{T} \quad [7]$$

The application of the cointegration bound test approach is used to overcome differences in integration levels and optimal lags for each variable (Pesaran et al, 2001). The cointegration of the bound test approach by estimating the long-term coefficient value with f-count.

The next step, along with estimating the long-term coefficients, is capable of estimating the short-term coefficients of all variables incorporated in the model through the ARDL approach of the error correction format. Through the format error correction mechanism (ECM) it can be determined the speed of adjustment of the direction of the balance of Pesaran and Pesaran (1997) with the following equation:

$$\emptyset(L)y_t = a_0 + a_1 t + \beta' x_t + \textstyle\sum_{i=0}^{q-1} \beta_j^{*\prime} \Delta x_{t-j} - \emptyset^*(L)\,\Delta y_t + \mu_t \quad [8]$$

Where $\emptyset(L) = 1 - \sum_{j=1}^{p} \emptyset_j L^j$, and $\emptyset(L) = 1 - \sum_{j=1}^{p} \emptyset_j L^j$ are variable of dependent, x_t is the independent variable and L is the lag operator. The ARDL model based on Pesaran et al (2001) requires an Error Correction Model (ECM) with the adjustment method and error correction in the short term to achieve equilibrium in the long term, as expressed by the following formula:

$$\Delta y_t = c_0 + c_1 t + \pi_{yy} y_{t-1} + \pi_{yxx} x_{t-1} + \sum_{i=1}^{p-1} \varphi'_i \Delta z_{t-i} + w'^{\Delta x_t} + \mu_t \quad [9]$$

Prior to interpretation, the results of simultaneous regression in this study had undergone diagnostic tests including tests for autocorrelation, multicollinearity, normality and heteroscedasticity.

3. RESULTS AND DISCUSSION

Unlike the other cointegration tests, the ARDL cointegration test does not have to be at the same stationary. Continuation of ARDL model estimation is possible when the variables are either stationary at level I(0) or I(1), or when all variables exhibit stationarity at order I(1). In the cointegration test, the Philips Perron root test is used in this research to test the stationarity variables in the model. Table 1 and 2 below show the stationary results for each variable of unit root test Indonesia and India. The data meets the criteria for utilizing the ARDL approach as an appropriate tool for analysing long and short-term relationships since all variables are stationary at first difference.

Table 1. Unit Root Test of Indonesia

Variables	PP test statistic of Indonesia	
	Constant	Constant and trend
CO2	-7.922662***	1.665199
GDP	-5.980833***	3.520808***
GDP^2	-6.037521***	4.320292***
EC	-3.171869***	3.260331***
TB	-6.119106***	1.219106

Table 2. Unit Root Test of India

Variables	PP test statistic of India	
	Constant	Constant and trend
CO2	-8.280430***	4.622863***
GDP	-7.450133***	4.878632***
GDP^2	-7.369629***	4.408071***
EC	-8.838624 ***	3.852636***
TB	-7.776485***	-1.228807

Moreover, the ARDL approach necessitates lag selection, and the optimal lag is determined using the Akaike Information Criterion (AIC). Lag sequence selection is imperative to ensure unbiased and reliable results. This indicates the maximum lag length chosen in the estimation model. The selected model (optimal lag order) for Indonesia includes a lag of 4 for CO2, no lag for GDP, a lag of 1 for GDP square, no lag for EC, and a lag of 4 for TB. Subsequently, the F statistic surpasses the critical value (5%) at approximately 14.9570, signifying cointegration among the variables. Conversely, the selected model (optimal lag order) for India involves a lag of 1 for CO2, a lag of 3 for GDP, a lag of 2 for GDP square, no lag for EC, and a lag of 4 for TB. In this case, the F statistic exceeds the critical value (5%) at about 22.578, indicating cointegration among all of variables.

Then, in ARDL, it is essential to conduct a stability test. Stability tests are employed to assess short-term and long-term parameters. Thus, CUSUM and CUSUMSQ were carried out in this study. Based on the stability test results in Figures 3 and 4, it shows that the parameters in Indonesia are stable from time to time.

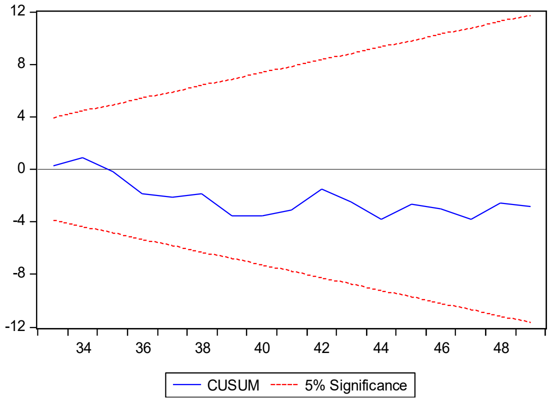

Figure 5. CUSUM Test of Indonesia

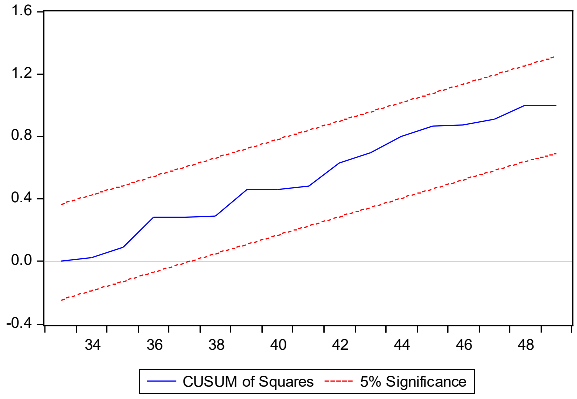

Figure 6. CUSUMSQ Test of Indonesia

Based on the stability test results in Figures 5 and 6, it shows that the parameters in India are also stable from time to time. The blue line is stable in the middle and does not cross the red line.

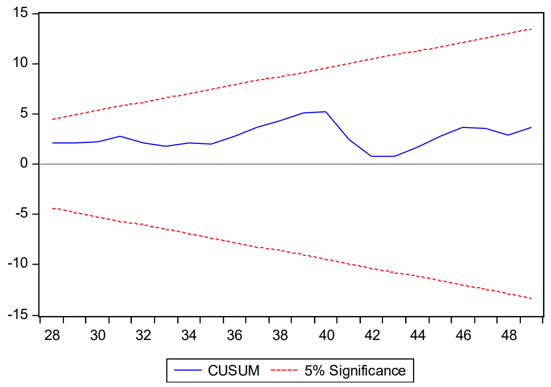

Figure 7. CUSUM Test of India

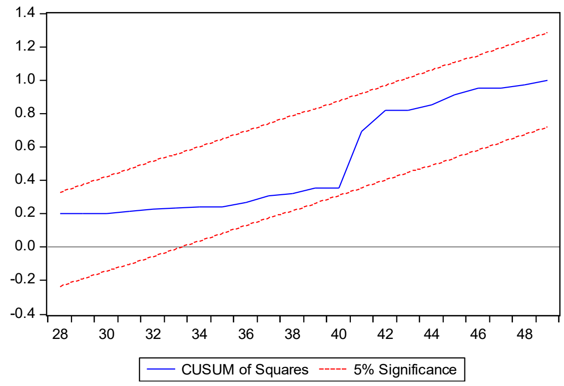

Figure 8. CUSUMQ Test of India

Futhermore, Table 3, the short-term estimation results for Indonesia are displayed. The estimation results show that all variables have an effect on CO2 emissions. First, GDP has a positive and significant effect on CO2 emissions. It means that when the GDP increases so the emission of CO2 also increases in short term. The more economic activities carried out will increase CO2 emissions. Economic activity can be in the form of economic development, industrial development, and all activities with the aim of improving the economy. It will make the CO2 gas more produced. Moreover, Indonesia is a developing country that has not really thought about how to deal with increasing CO2. The findings contrast with A'yun and Khasanah's (2022) assertion that carbon dioxide emissions in ASEAN countries are negatively and significantly impacted by economic growth. In the short term, emission CO2 exhibits a positive and significant effect on GDP square. This discovery prompts an intriguing discussion as, in the short term, both the coefficient of GDP and GDP square demonstrate positivity. This suggests that the Environmental Kuznets Curve (EKC) hypothesis cannot be confirmed in Indonesia in the short term. Similar results have been reported by Nikensari (2019), Umaroh (2019), Noor, and Saputra (2020).

Table 3. Short Run Estimation of Indonesia

Dependent variable = Co2 of Indonesia			
Variable	**Coefficient**	**Standard error**	**t-statistic**
GDP	0.000622	0.000133	4.682082***
GDP^2	1.730016	5.230017	3.311295***
EC	42241.89	5228.563	8.079063***
TB	0.000753	0.000308	2.448155***
ECM_{t-1}	-0.861581	0.085626	-10.06218***
Statistics			
R-squared		0.86	
S.E of regression		8878	
AIC		34.98	
F-statistic		14.957	

Table 4. Long Run Estimation of Indonesia

Dependent variable = Co2 of Indonesia			
Variable	**Coefficient**	**Standard error**	**t-statistic**
GDP	-9.250006	7.040017	-0.069959
GDP^2	-2.010016	0.000132	-2.854259***
EC	49028.36	6962.320	7.041958***
TB	0.0000874	0.000308	2.746728***

Table 5. Short Run Estimation of India

Dependent variable = Co2 of India			
Variable	**Coefficient**	**Standard error**	**t-statistic**
GDP	0.000199	0.000218	0.913014
GDP^2	8.310017	4.340017	1.913559*
EC	185408.0	8.050005	4.188896***
TB	0.000167	0.000152	1.092575
ECM_{t-1}	-0.702399	0.056417	-12.4501***
Statistics			
R-squared		0.97	
S.E of regression		11330	
AIC		35.50	
F-statistic		22.758	

Table 6. Long Run Estimation of India

Dependent variable = Co2 of India			
Variable	**Coefficient**	**Standard error**	**t-statistic**
GDP	0.000480	9.460005	5.075226***
GDP^2	-1.170016	3.720017	-3.152251***
EC	263963.9	18642.68	14.159911**
TB	-0.001810	0.000308	-5.874983***

In the long term, as depicted in Table 4, the hypothesis of Environmental Kuznets Curve (EKC) cannot be confirmed. This can be ascribed to the fact that GDP is statistically insignificant concerning CO2 emissions, and the GDP square has a negative significant correlation with CO2. It means that, in the long term, an increase in GDP is associated with a reduction in CO2 emissions in Indonesia, indicating an augmented awareness of the environment by both the government and the public. However, despite the positive trend in environmental consciousness and endeavors toward sustainable development in Indonesia, the long-term results of this study do not align with the EKC hypothesis. The noteworthy negative and significant relationship between GDP and CO2 emissions suggests that, as the economy grows, there is a concurrent reduction in CO2 emissions. This may suggest a heightened awareness of the environmental impacts of economic activities, leading to the implementation of measures to mitigate CO2 emissions.

Nevertheless, it is crucial to acknowledge that the lack of significance for the GDP square variable implies an absence of evidence supporting an inverted U-shaped relationship between economic growth and CO2 emissions in the long term. This particular finding challenges the conventional notion that, as the economy continually expands, a turning point will be reached where environmental degradation starts to decline. This stands as a distinctive observation in contrast to the analyses conducted by A'yun and Anggrayni (2023), which indicated a long-term impact of economic growth on CO2 emissions in the United States.

In Table 5, the results of short-term estimation for India reveal that GDP does not exert a significant impact on CO2 emissions. This implies that, in the short term, there is no direct correlation between economic growth and CO2 emissions in India. One plausible explanation for this outcome could be that, as a developing nation, India is currently undergoing rapid industrialization and heightened economic development, resulting in increased CO2 emissions irrespective of GDP levels.

Conversely, the positive and significant impact of GDP square on CO2 emissions at a 10 percent significance level suggests a potential non-linear relationship between economic growth and CO2 emissions in the short term. As GDP surpasses a certain threshold, there appears to be an associated increase in CO2 emissions. This discovery challenges the Environmental Kuznets Curve (EKC) hypothesis in the short term, deviating from the anticipated inverted U-shaped relationship.

However, delving into the long-run estimation results presented in Table 6, the hypothesis of the EKC in India finds support. The negative and significant impact of GDP on CO2 emissions, coupled with the positive and significant effect of the GDP square, aligns with the theoretical expectations of the EKC hypothesis. This suggests that, in the long term, as GDP per capita continues to rise, the influence on CO2 emissions, as a proxy for environmental degradation, gradually diminishes. This observed pattern conforms to a U-shaped curve, consistent with the predictions of the EKC theory.

Therefore, the long-term findings imply that despite an increase in GDP per capita, there will be a reduction in CO2 emissions in India. This suggests that as India undergoes economic progress, it may adopt more sustainable practices and implement policies aimed at mitigating environmental degradation, resulting in a gradual decrease in CO2 emissions over time.

4. CONCLUSIONS

The finding of this study shows that hypothesis EKC cannot prove in Indonesia both in short term and long term. However, the hypothesis EKC can prove in India in long run, not in short run. It means that in India the shape of EKC is U curve or U-shape between the relationship of GDP per capita to CO2 emissions.

5. REFERENCES

A'yun, Indanazulfa Q. and Anggrayni, Devi. (2023), "Determinants of CO2 Emission: Evidence from United States", Journal of Economics Research and Social Sciences, Vol 7 No 2, pp. 175-191.

A'yun, Indanazulfa Q. and Khasanah, Uswatun. (2022), "The Impact of Economic Growth and Trade Openness on Environmental Degradation: Evidence from A Panel of ASEAN Countries", Jurnal Ekonomi & Studi Pembangunan, Vol. 23 No.1 pp. 81-92.

Alshehry, A.S. and Belloumi, M. (2015), "Energy consumption, carbon dioxide emissions and economic growth: the case of Saudi Arabia", Renewable and Sustainable Energy Reviews, Vol. 41, pp. 237-247.

Bekun, F.V., Emir, F. and Sarkodie, S.A. (2019), "Another look at the relationship between energy consumption, carbon dioxide emissions, and economic growth in South Africa", Science of The Total Environment, Vol. 655, pp. 759-765.

Canh, N.P., Thanh, S.D., Schinckus, C., Bensemann, J. and Thanh, L.T. (2019), "Global emissions: a new contribution from the shadow economy", International Journal of Energy Economics and Policy, Vol. 9 No. 3, pp. 320-337.

Chen, C., Pinar, M., dan Stengos, T. (2022) Renewable Energy and CO2 emissions: New evidence with the panel threshold model. Renewable Energy, Vol. 194, 117-128.

Cahyadin,M.,Sari,V.K.,&Juwita,A.H.(2021).New Evidence of Environmental Kuznets Curve Hypothesis in Developing Countries. Jurnal Ekonomi Pembangunan: Kajian Masalah Ekonomi Dan Pembangunan, 22(2), 251–262. https://doi.org/10.23917/jep.v22i2.15794

Esen, O. and Bayrak, M. (2017), "Does more energy consumption support economic growth in net energy-importing countries?", Journal of Economics, Finance and Administrative Science, Vol. 22 No. 42, pp. 75-98.

Ghazouani, T., Boukhatem, J. and Yan Sam, C. (2020), "Causal interactions between trade openness, renewable electricity consumption, and economic growth in Asia-Pacific countries: fresh evidence from a bootstrap ARDL approach", Renewable and Sustainable Energy Reviews, Vol. 133, July, p. 110094.

Goetzke, Frank, and Tilmann Rave. 2015. "Regional air quality and happiness in Germany." International Regional Science Review 38 (4):437-451.

Jun, W., Mahmood, H. and Zakaria, M. (2020), "Impact of trade openness on environment in China", Journal of Business Economics and Management, Vol. 21 No. 4, pp. 1185-1202.

Karedla, Y., Mishra, R., dan Patel, N. (2021). The impact of economic growth, trade openness and manufacturing on CO2 emissions in India: an autoregressive distributive lag (ARDL) bounds test approach. Journal of Economics, Finance and Administrative Science, Vol. 26 No. 52, 2021 pp. 376-389.

Kılavuz, E. and Dogan, _I. (2020), "Economic growth, openness, industry and CO2 modelling: are regulatory policies important in Turkish economies?", International Journal of Low-Carbon Technologies, Vol. 16 No. 2, pp. 476-487.

Landrigan, Philip J. 2017. "Air pollution and health." The Lancet Public Health 2 (1):e4-e5.

Lin, B., Moubarak, M. and Ouyang, X. (2014), "Carbon dioxide emissions and growth of the manufacturing sector: evidence for China", Vol. 76, 2014, pp. 830-837.

Lin, F. (2017), "Trade openness and air pollution: city-level empirical evidence from China", China Economic Review, Vol. 45, pp. 78-88

Nikensari, Sri Indah, Destilawati, Sekar, dan Nurjanah, Siti. (2019). Study of Environmental Kuznets Curve in Asia: Before and After Millennium Development Goals. Jurnal Ekonomi dan Pembangunan, Vol. 27 no. 2 pp. 11-25.

Noor, M. A. and Saputra, P. M. A. (2020). Carbon Emission and Gross Domestic Prouduct: A Hypothetical Investigation on

Environmental Kuznets Curve (EKC) in ASEAN Middle-Income Countries. Jurnal Wilayah dan Lingkungan, Vol. 8 no.3 pp. 230-246.

Purcel, A.A. (2020), "New insights into the environmental Kuznets Curve Hypothesis in developing and transition economies: a literature survey", Environmental Economics and Policy Studies, Vol. 22, doi: 10.1007/s10018-020-00272-9.

Shahbaz, M. and Sinha, A. (2019), "Environmental Kuznets curve for CO2 emissions: a literature survey", Journal of Economic Studies, Vol. 46 No. 1, pp. 106-168.

Song, Z. (2021), "Economic growth and carbon emissions: estimation of a panel threshold model for the transition process in China", Journal of Cleaner Production, Vol. 278, p. 123773.

Spilker dkk. (2017). International Political Economy and the Environment. Oxford Research Encyclopedia.

Susilowati, I., Silahul Mu, M., Qudsyina, H., Asri Wahyuni, H., Rismawati, S., Ayu Kusumawardhani, H., & Ruyel Miah, M. (2023). Nexus Between Economic Growth, Renewable Energy, Industry Value Added and CO 2 Emissions in A S E A N. 24(2), 265–281. https://doi.org/10.23917/jep.v24i1.23165

Tenaw, D. dan Beyene, A. (2021). Environmental sustainability and economic development in sub-Saharan Africa: A modified EKC hypothesis. Renewable and Sustainable Energy Reviews, 143 (2021) 110897.

Tol, R.S.J. (2012). On the uncertainty about the total economic impact of climate change. Environmental and Resource Economics, 53, 97-116.

Umaroh, Rodhiah. (2019). Does Education Reduce CO2 Emissions? Empirical Evidence of The Environmental Kuznets Curve in Indonesia. Journal of Reviews on Global Economics, Vol. 8, 662-671.

Wang, Q. and Zhang, F. (2021), "The effects of trade openness on decoupling carbon emissions from economic growth – evidence from 182 countries", Journal of Cleaner Production, Elsevier, Vol. 279, p. 123838.

WEF. (2017). Global Shapers Survey. Global Shapers Community. Retrieved from http://www.shaperssurvey2017.org/static/data/WEF_GSC_Annual_Survey_2017.pdf

Wen, H. and Dai, J. (2020), "Trade openness, environmental regulation, and human capital in China: based on ARDL cointegration and Granger causality analysis", Environmental Science and Pollution Research, Vol. 27 No. 2, pp. 1789-1799.

Zafar, A., Ullah, S., Majeed, M.T. and Yasmeen, R. (2020), "Environmental pollution in Asian economies: does the industrialisation matter?", OPEC Energy Review, Vol. 44 No. 3, pp. 227-248.

Zhang, Xin, Xiaobo Zhang, and Xi Chen. 2017. "Happiness in the air: how does a dirty sky affect mental health and subjective well-being?" Journal of environmental economics and management 85:81-94.