KnE Social Sciences
IRCEB
The 6th International Research Conference on Economics and Business
Volume 2024

Research Paper

Environmental Kuznets Curve Hypothesis: Before and After Sustainable Development Goals

Herdi Yudha Rahman*, Firsty Ramadhona Amalia Lubis, Muhammad Arsy R.G.P, Risya Yuandita , Rifki Khoirudin

Department of Economic Development, Faculty of Economic and Business, Ahmad Dahlan University

ORCID
Herdi Yudha Rahman: https://orcid.org/0000-0003-3412-6288

Abstract.
The Environmental Kuznets Curve (EKC) hypothesis is an idea that examines the inverse "U" curve relationship between environmental degradation and economic development. This study contributes to analyzing the application of EKC hypothesis in G20 participating countries, as well as the relationship between the variables of gross domestic product (GDP), foreign direct investment (FDI), population, and renewable energy on environmental degradation represented by ecological footprint variables in the same area by comparing the period before and after the implementation of the SDGs. This study uses the panel data regression method for the period 2011-2018, where data is obtained from the World Bank and the Global Footprint Network. The results show that from 2011-2018 the EKC hypothesis formed an inverted U-curve. This study also shows that before the SDGs (2015) the variables of GDP, FDI, population, and renewable energy had an effect on increasing the value of the ecological footprint. Meanwhile, after the implementation of the SDGs program, the variables of GDP, FDI, population, and renewable energy contributed to reducing the value of the ecological footprint, which indicated a decrease in people's dependence on natural resources. Where the GDP variable has a positive and significant effect and the renewable energy variable has a negative and significant effect. While FDI and population variables have a positive but insignificant effect.

Keywords: EF, EKC, FDI, GDP, GDP2, POP, RE, SDGs

Corresponding Author: Herdi Yudha Rahman; email: herdi1900010122@webmail.uad.ac.id

Published 24 January 2024

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the 4th INCLAR Conference Committee.

1. Introduction

One of the causes of environmental degradation is the advancement of society and the growth of development that is focused on advancing human welfare, which results in a yearly decline in the quantity of raw materials that the natural environment can provide as well as the function or role of the environment (Hajar, 2017). This can have a negative impact on the patterns of local, national, and even global economic sustainability.

Global recognition of the reduction in environmental quality has prompted consideration of global climate change issues. where an immediate course of action or solution

is required. According to the National Oceanic and Atmospheric Administration (NOAA National Centers for Environmental, 2022) since 2016, there have been successive rises in global surface temperatures that have been nominally above the average for the 20th century.

Suitability between the economy, the environment, and the management of natural resources is necessary for sustainable economic growth (NR). The three instruments are interconnected and form a cohesive whole that is challenging to distinguish from one another. When natural resources are used responsibly and within their usage and absorption limits, sustainable economic growth can be attained. Paying attention to the utilization of renewable natural resources which, in their use, do not diminish or destroy their function for the sustainability of future interests—is also essential to achieving sustainable economic growth. When using non-renewable resources, it is important to consider their natural availability threshold (Priyagus, 2017).

This is one of the objectives of the Sustainable Development Goals (SDGs), a program that replaces the Millennium Development Goals (MDGs), which will be completed in 2030. One of the MDGs development agendas that is still being implemented in the MDGs program relates to climate change, the deterioration of environmental quality brought on by economic activity, and achieving sustainable development by balancing the three sectors of environmental, social, and economic factors (Nikensari et al., 2019).

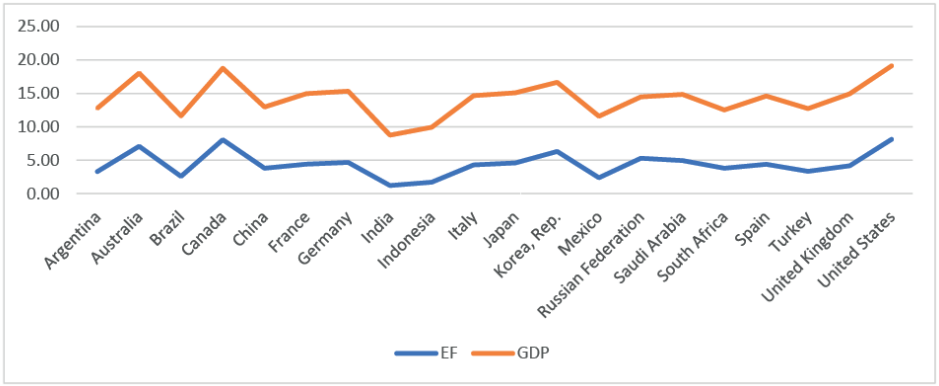

Figure 1: Ecological Footprint and GDP Level in G20 Participating Countries 2018. *Source : Global Footprint Network(GFN) & World Bank,(2022).*

According on **Figure 1**, economic growth and the Ecological Footprint (EF) of the G20 member countries are correlated linearly. This demonstrates that economic development, such as the construction of infrastructure, the expansion of industry, or the clearance of open land, will directly affect the environment's capacity to handle the waste generated by economic activity.

Using the Environmental Kuznets Curve (EKC), which was made popular by Grossman and Krueger, economists have examined the relationship between economic growth rates and environmental indices (1995). The inverted U-curve, which the EKC hypothesis interprets as the turning point, indicates that environmental degradation will slowly decline as a result of technological advancements and the move to a service-based economy at the peak of economic growth. Environmental degradation will rise with economic development. (Alvarado & Toledo, 2017).

Most of the studies studying the EKC hypothesis measure environmental degradation through the level of CO2 emissions, but in this case, the Ecological Footprint variable is used. Although there are limits in the updating of the data that is currently available on these variables, this also happens with other factors related to environmental degradation that take a long time to produce a valid assessment of the value of environmental degradation in a region.

The primary goal of this study was to analyze the state of EKC in G20 participating countries before and after the implementation of the SDGs program, based on the research of Nikensari et al., (2019), who previously investigated the state of EKC in Asia before and after the implementation of the MDGs program. In addition, Ibrahim et al., (2022) used the same study focus to determine the reliability of the EKC hypothesis before and after the SDGs program was implemented in West Java.

2. Literature Review

The Sustainable Development Goals (SDGs) are a collection of objectives, benchmarks, and metrics for universal and sustainable development that the United Nations announced from the end of 2015 to 2030. (Pratama, 2020). The MDGs, which have 17 goals and 169 targets, were not met to a large extent, which led to the creation of the SDGs. Poverty, Food, Health, Education, Women, Water, Energy, Economy, Infrastructure, Settlements Inequality, Consumption, Climate, Ecosystems, Institutions, and Sustainability are among the 17 goals of the SDGs.

The amount of human requirements that are derived from the environment over a specific time period is determined using the ecological footprint as a measuring method. According to Wackernagel and Rees' research, the ecological footprint is the amount of land and water in various classifications that a community needs in a given region to satisfy ongoing demand for natural resources and the capacity of the environment to absorb created waste (Galli et al., 2020).

A reduction in the environment's capacity to accommodate different human activities is a sign of environmental degradation. An equation that can quantify the presence of environmental damage is developed by Barbier et al., (1990).

$$S = f\left([W - A],\ [(R - G) + E]\right)$$

Equation 1 -- Environmental Damage Measurement

Based on **Equation 1** that can be explained, environmental degradation or a decrease in environmental quality (S) is the impact caused by the existence of two outputs. First, the waste generated (W) is more than the environment's ability to accommodate the waste (A). Second, the use of renewable natural resources (R) is greater than the ability of nature to regenerate its natural resources (G). Utilization of non-renewable natural resources (E), where these components have been used as one of the causes of environmental degradation because the renewal takes a long time. Uncontrolled use of natural resources can reduce the supply of natural resources in the environment over time.

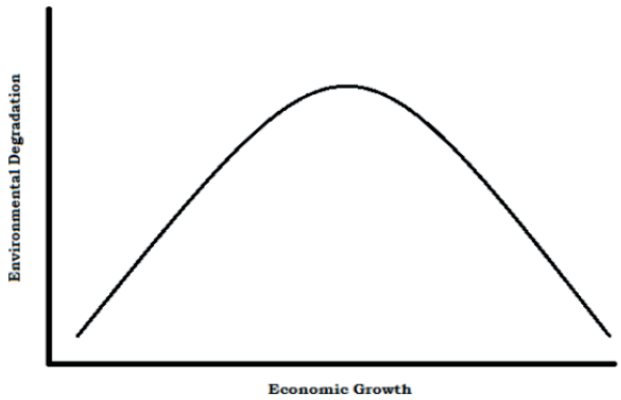

Figure 2: *Environmental Kuznets Curve* (EKC). *Sumber: Kasten(2015).*

The Environmental Kuznets Curve is a theory that explains how economic growth and environmental quality are related (EKC). Economic Growth and Income Inequality (1995), a research hypothesis by Simon Kuznets, is credited with the development of this idea. The influence of economic expansion on environmental quality will be explained by the EKC hypothesis. **Figure 2** shows that the commencement of economic growth will result in excessive pollution. However, when the economy is thought to be doing better, awareness of the value and expensive cost of good environmental quality will rise (Mosconi et al., 2020).

3. Method

This study uses descriptive quantitative methods using secondary data obtained from GFN and the World Bank. To support this, a regression method was used from 20 member countries of the G20 participants in the 2011-2018 period. With variable data which includes ecological footprint, gross domestic product, foreign direct investment, population, and renewable energy. To determine the best and most appropriate model in estimating panel data can be seen in **Figure 3**.

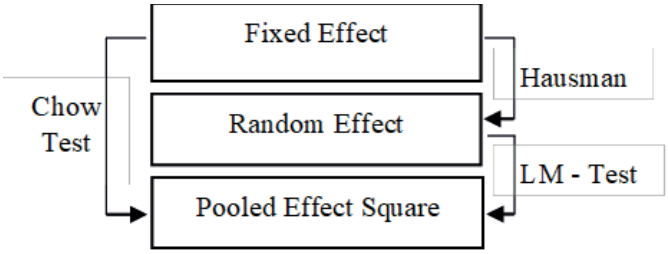

Figure 3: Panel Data Testing Flow.

Referring to Ibrahim et al., (2022), Nikensari et al., (2019), dan Silvia et al., (2021), the regression equation can be formulated as follows.

$$EfCap_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP^2{}_{it} + \beta_3 FDI_{it} + \beta_4 POP_{it} + \beta_5 RE_{it} + \beta_6 du\_SDGs + e_{it}$$

Equation 2 -- Panel Regression Model

Where: EFCap is the ecological footprint per capita, GDP is the GDP per capita variable, GDP2 is the GDP per capita squared, FDI is the foreign direct investment, POP is the population, RE is the renewable energy, du_SDGs is the dummy variables before and after SDGs, β0 is a constant, β1- β5 is the regression coefficient, e is the error term, i to indicate the object, and t to indicate the time. Based on these equations, in calculating and estimating the implementation of the hypothesis, *Environmental Kuznets Curve*(EKC) in the G20 participating countries, is based on the following equation (Nikensari et al., 2019).

1. When $\beta 2 < 0$, an inverted U-shaped relationship occurs
2. When $\beta 2 \geq 0$, U-shaped relationship occurs
3. Turning point = $\frac{\beta 1}{2\beta 2}$

From these equations it can be concluded that the hypothesis *Environmental Kuznets Curve* (EKC) proven significant if the value of GDP per capita is positive while the value of GDP2 per capita is negative.

4. Results And Discussion

4.1. Best Model Selection

Table 1: Selection of the Best Model.

Variabel	CEM	FEM	REM
gdp	0.000* (2.33)	0.000*** (3.32)	0.000*** (4.83)
gdp2	2.88 (0.76)	-2.38*** (-3.58)	-1.91*** (-3.57)
fdi	3.19* (2.54)	6.19 (0.21)	6.14 (0.11)
pop	-7.25* (-2.43)	9.99** (0.04)	3.59 (0.51)
re	-0.03*** (-4.61)	-0.058* (-3.21)	-0.055*** (-3.67)
du_sdgs	-0.21 (-1.31)	-0.12** (-2.35)	-0.148** (-3.43)

t statistics in parentheses
** p<0.05, ** p<0.01, *** p<0.001*
Source: Data processed Stata.14

The outcomes of the panel data model calculations for Common Effects, Fixed Effects, and Random Effects are presented in **Table 1** below. The Fixed Effect (FE) Model is the most appropriate model for this study, according to the findings of the Chow test. However, the Hausman and Lagrangian Multiplier (LM) tests explain that the Random Effect (RE) Model is superior to both the FE and CE models. According to **Table 2**, the chow test has a probability of 0.000 or Prob. 0.05, which means that H0 is rejected and H1 is accepted or FE is a better model.

Table 2: Best Model Test.

Model	f-stat.	Prob.
Uji Chow	141.3	0.000
Uji Hausman	1.79	0.619
Uji Lagrangian Multiplier	465.7	0.000

Source: Data processed Stata.14

Meanwhile, the Hausman test is used to determine if the FE or RE model is more effective. With a probability value of 0.619, or Prob. > 0.05, these data show that H0 is accepted and H1 is rejected, demonstrating that REM is a superior model to FE. Additionally, the LM test demonstrates that the RE model outperforms the CE model. Therefore, it may be said that RE is the optimal model to utilize.

4.2. Classic assumption test

The autocorrelation test findings indicate a likelihood of less than 0.05, indicating the presence of an autocorrelation issue. However, according to research by Kuswantoro

(2009), assumptions that are free from serial or correlation issues are not necessary for panel data regression analysis utilizing the Random Effect Model technique. There is no conventional assumption problem for the multicollinearity test and the normalcy test.

4.3. Regression Analysis Statistical Test Results

TABLE 3: Regression Analysis Statistical Test.

Variabel	Coef. Std.	t	P>t
gdp	0.000177	4.83	0.000
gdp2	-1.91e-09	-3.57	0.000
fdi	6.14e-14	0.11	0.909
pop	3.59e-10	0.51	0.612
re	-0.054790	-3.67	0.000
du_sdgs	-0.147981	-3.43	0.001
_cons	2.634991	3.87	0.000

Source: Data processed Stata.14

Based on the results of the data presented in **Table 3**, the following equation can be obtained::

$$EfCap_{it} = \beta_0 + 0.000177\, GDP - 1.91e{-}09\, GDP^2 + 6.14e{-}14\, FDI + 3.59e{-}10\, POP - 0.0547907\, RE$$

Equation 3 -- Regression Test Results

Based on **Table 3**, it was discovered that the Adjusted R-squared value was 0.5909, meaning that the variables gross domestic product, foreign direct investment, population, and renewable energy were able to influence the ecological footprint variable by 59.09%, while other variables outside the model had an influence on 40.91% of it. regression. According to the F test results, the variables GDP, GDP2, FDI, population, and renewable energy all simultaneously affect the ecological footprint variable at a significant level of =1%, with a probability F value of 0.0000..

Table 3 shows that, with a probability value of 0.000 to 0.05, GDP in the nations that participated in the G20 from 2011 to 2018 has a positive and significant impact on ecological footprint. This demonstrates that, in the G20 countries, economic expansion is still associated with rising demand for natural resources. According to research done by Santi & Sasana (2020), an increase in economic growth, which is indicated by an increase in economic activity and an increase in a country's industry, will result in an increase in the demand for natural resources needed for economic activity and an increase in the level of economic activity.Absorption land will be more necessary as population growth, industrial waste production, and waste from economic activity all

produce waste. GDP2's coefficient of -1.91, which denotes a negative estimation sign and explains why GDP has a non-linear (quadratic) relationship with environmental degradation, is for the GDP quadratic variable. This outcome is in line with the EKC hypothesis, which has the shape of an inverted U-curve and predicts that environmental degradation will rise as GDP per capita rises up to a turning point ($\beta 1/[2\beta 2]$) = USD 46,335 before declining as GDP rises after it passes the turning point.

FDI have a probability value more than the significance threshold value of 5%, the FDI variable has a positive and inconsequential impact on the ecological footprint in the 2011–2018 G20 participating countries. This contradicts the study by Silvia et al. (2021), which found that the FDI variable has a favorable and significant impact. However, FDI contributes to environmental degradation since it increases output in a country, which results in pollution and other environmental damage.

With a probability value more than the significance level value of 5%, the population variable has a positive but minor impact on the ecological footprint in the 2011–2018 G20 participating countries. This contradicts the findings of Nikensari et al., (2019), which shows that the population variable has a favorable and significant impact. The population, due to some individuals' consumptive behavior toward excessive natural resources and ecologically unfriendly waste disposal, is the primary contributor to environmental degradation.

The variable of renewable energy has a negative and considerable effect on the ecological footprint in the G20 participating nations from 2011 to 2018. This demonstrates how using renewable energy can lessen people's reliance on non-renewable resources, and how doing so can also lessen environmental deterioration and make renewable energy generally more hygienic and environmentally friendly. Despite the fact that renewable energy usage is still disproportionately higher than the consumption of non-renewable energy,

The ecological footprint in the G20 participating countries between 2011 and 2018 is negatively and significantly impacted by the Dummy Variable SDGs, with a probability value less than the significance level value = 5%. This demonstrates that there is a significant association between the ecological footprint and the Dummy Variable SDGs. negative, which means that the Dummy Variable SDGs minimize the amount of environmental harm by 0.1479813 global hectare (gha). This demonstrates that the SDGs program's effect, particularly among the G20 member countries, is quite capable of addressing a number of environmental issues related to environmental degradation.

5. Conclusions

The study's findings support the EKC hypothesis, which forms an inverted U-curve in the G20 participants' countries between 2011 and 2018. This study also demonstrates that while the GDP variable has a positive and large impact on the ecological footprint, the FDI and Population factors have a positive but minor impact. The Ecological Footprint is negatively and significantly impacted by GDP2, Renewable Energy, and Dummy Factors SDGs variables. The Dummy Variable SDGs are able to lower the amount of environmental harm caused by the Ecological Footprint by 0.148 global hectares as a result of the negative connection between the Dummy Variable SDGs and the Ecological Footprint (gha). This demonstrates that the SDGs program's effect, particularly among the G20 member countries, is quite capable of addressing a number of environmental issues related to environmental degradation. The SDGs programs that are focused on environmental issues in connected countries may be improved and re-optimized by G20 participating nations. This can also be done by increasing the use of renewable energy to minimize the use of non-renewable energy, which is obviously the use of renewable energy. more ecologically friendly and cleaner.

ACKNOWLEDGEMENT

The author would like to thank all those who have helped so that this scientific journal can be completed. The author's special thanks go to the Development Economics Study Program, Faculty of Economics and Business, Ahmad Dahlan University for allowing this journal to be published.

References

[1] Alvarado R, Toledo E. Environmental degradation and economic growth: evidence for a developing country. Environ Dev Sustain. 2017;19(4):1205–1218.

[2] Barbier EB, Markandya A, Pearce DW. Environmental sustainability and cost-benefit analysis. Environ Plann A. 1990;22(9):1259–1266.

[3] Galli A, Iha K, Moreno Pires S, Mancini MS, Alves A, Zokai G, et al. Assessing the ecological footprint and biocapacity of Portuguese cities: Critical results for environmental awareness and local management. Cities. 2020;96:102442.

[4] Hajar I. Peran Center for Internasional Forestry Research (CIFOR) Di Indonesia Terkait Mekanisme Reducing Emission from Deforestation and Forest Degradation (REDD)

2007-2014. Jurnal Online Mahasiswa Fakultas Ilmu Sosial Dan Ilmu Politik Universitas Riau. 2017;4(1):1–10.

[5] Ibrahim MD, Hasyim M, Abbas I. Existence of the Environmental Kuznets Curve and its relevance to SDGs policy : A study in Java region. Indonesia. 2022;5(2):162–174.

[6] Mosconi EM, Colantoni A, Gambella F, Cudlinová E, Salvati L, Rodrigo-Comino J. Revisiting the environmental kuznets curve: The spatial interaction between economy and territory. Economies. 2020;8(3). https://doi.org/10.3390/economies8030074

[7] Nikensari SI, Destilawati S, Nurjanah S. Studi Environmental Kuznets Curve Di Asia: Sebelum Dan Setelah Millennium Development Goals. Jurnal Ekonomi Pembangunan. 2019;27(2):11–25.

[8] Pratama YP. Konsensus Kemitraan Global PBB (MDGs & SDGs), Hipotesis Environmental Kuznets Curve (EKC), dan Degradasi Kualitas Udara di Indonesia Periode 1980-2018. Diponegoro Journal of Economics. 2020;9(4):1–15.

[9] Priyagus. Pertumbuhan Ekonomi dan Degradasi Lingkungan Air di Wilayah Kalimantan dan Indonesia Analisis Enviromental Kuznet Curve (EKC). FEB-UNMUL : Samarinda. 2017;1:223–231.

[10] Santi R, Sasana H. Analisis Pengaruh Pertumbuhan Ekonomi, Jumlah Penduduk, Foreign Direct Investment (FDI), Energi Use/Consumption dan Krisis Ekonomi Terhadap Kualitas Lingkungan Ditinjau dari Tingkat Carbon Footprint di ASEAN 8. Diponegoro Journal of Economics. 2020;2(2):1–11.

[11] Silvia M, Astuti W, Rahmayani D. Analisis Pengaruh Investasi Langsung Asing dan Pertumbuhan Ekonomi Terhadap Degradasi Lingkungan di Negara ASEAN Berpendapatan Menengah. Seminar Nasional Fakultas Ekonomi Universitas Tidar. 2021;(September):25–32.