The Correlation Role of Carbon Emissions and Renewable Energy and Their Impact on Economic Growth in Indonesia

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Abstract

Carbon emissions and renewable energy use will be evaluated to see how they affect Indonesia's GDP development. For this study, we rely on information from the World Bank that covers the years 1991 through 2020. Researchers employ carbon dioxide (CO2) emissions, renewable energy (RE) consumption, and GDP as independent variables. Vector autoregressive (VAR) analysis was performed on these variables. As a result of higher emissions in the past, the trend of carbon emissions is currently upward. Consumption of renewable energy sources, on the other hand, has contributed to economic expansion in the past. If there is a positive association, it will aid in the creation of a sustainable economy. The continued growth of renewable energy is something that should be encouraged through regulations that promote its use. Direct investment is one example of a macroeconomic policy that has to be supported and harmonised with energy efficiency programmes to ensure both economic development and environmental sustainability.

Keyword: CO2 Emissions, Renewable Energy Consumption, GDP.
JEL Clasification: Q53, Q20, O47.
DOI : 10.54204/splashmagzvol3no12023002

Background

Carbon emission cuts, increased use of renewable energy, more FDI, increased exports, and a higher savings rate might all have a significant impact on the BRICS economy. Carbon emissions, consumption of renewable energy, exports, FDI, and savings all contribute to long-term economic growth in the BRICS countries; however, increases in carbon emissions and FDI are dampened by higher interest rates and wider trade liberalisation, and vice versa. The widespread use of coal in China's energy sector, especially in the country's central and resource-rich regions, is a significant source of carbon emissions. As an added bonus, the digital economy cushions the blow of the coal-based energy infrastructure's impact on greenhouse gas emissions (Li et al., 2021). Renewable energy consumption dynamics result in a sizable increase in short-term CO2 emissions. The utilisation of renewable energy sources is associated with a positive shock that has a negative effect on CO2 emissions. The recent drop in FDI may help lessen the impact of carbon dioxide emissions. The quantity and quality of foreign direct investment (FDI) are useful measures of global environmental health. A long-term higher trend in renewable energy consumption would disclose just a moderately good effect, whereas a long-term decrease trend in CO2 emissions would indicate a reduction in pollution. Expenditure levels are positively correlated with carbon dioxide emissions, which have negative effects. The connection between commerce and environmental destruction is tenuous (Rehman et.al, 2021).

Renewable energy sources may help reduce carbon dioxide (CO2) emissions in the near term, but they have little long-term influence on environmental quality. Ecological degradation is not accelerated by using renewable energy. One possible explanation is that ASEAN countries

aren't making enough use of eco-friendly forms of power. Both tourism and FDI (foreign direct investment) lead to an increase in greenhouse gas emissions. The environment benefits from increased consumer spending power and unrestricted trade. In contrast to the greater CO2 emissions associated with economic growth at the outset of development, lower CO2 emissions are linked to economic growth once a critical mass of development has been established (Pata, Dam, & Kaya, 2023). Investments from outside the country tend to moderate energy use, which in turn reduces carbon emissions. These findings highlight the positive impacts of structural change on energy efficiency and long-term economic growth. Energy efficiency programmes must take into account macroeconomic and financial variables like FDI, economic growth, urbanisation, and trade if we are to achieve the lowest possible carbon emissions and guarantee environmental sustainability (Balsalobre-Lorente, Driha, Halkos, & Mishra, 2022; Widarni, Irawan, Harnani, Rusminingsih, & Alim, 2022).

The use of renewable energy and the way it interacts with the efficiency of governments and the flow of foreign investment are both good for the environment. Carbon emissions may be reduced in South Asian countries thanks to renewable energy, efficient government, and foreign investment. Therefore, it is imperative that policymakers and governments in these nations strengthen their reliance on renewable energy sources and work together with international investors in this space. To reach its sustainable development goals, the government must prioritise the development of renewable energy technologies and research (Mehmood, 2023 ; Prabowo, Sasongko, & Damayanti, 2022). Using renewable energy, tourism, FDI, trade, and savings might be very beneficial for the countries of Central and South America. Commerce and economic growth reduce emissions, while tourism, renewable energy, and FDI raise them. Attracting foreign direct investment, encouraging the use of renewable energy sources, and increasing tourism, especially green tourism, are all useful in the region's battle against climate change (Ben Jebli, Ben Youssef, & Apergis, 2019). Consumption of renewable energy sources reduces emissions of greenhouse gases, suggesting that they may eventually replace traditional energy sources. Carbon dioxide emissions' negative impact on renewable energy use exemplifies how environmental factors may affect the possibilities for renewable energy growth. Renewable energy's outstanding progress towards carbon neutrality is only one reason why experts think the green energy race will alter the geopolitical landscape of the world (Yuan et.al, 2022).

Over time, a shift towards renewable energy sources reduces greenhouse gas emissions while simultaneously boosting GDP and fostering monetary growth. While long-term trends show a negative correlation between carbon emissions and the use of renewable energy in South Africa, short-term trends show a positive correlation between GDP and financial development and carbon emissions. More has to be done in South Africa to encourage the use of renewable energy sources and greater efficiency in energy consumption. Energy efficiency programmes need to be coordinated with other macroeconomic and financial variables such as FDI, fiscal development, and trade openness to ensure that South Africa meets its environmental sustainability goals and produces the fewest possible carbon emissions (Ekwueme, Zoaka, & Alola, 2021). The purpose of this research is to examine the connection between carbon emissions and alternative energy sources, and their effect on Indonesia's economic development and growth.

Research Method

This study aims to provide light on the performance of carbon emissions and renewable energy sources as they relate to Indonesia's economic growth and development. The World Bank provides usable data for this study from the years 1991 through 2020. This analysis employs

the variables of carbon emissions, renewable energy, and GDP. The chosen model for testing is a Vector Autoregressive one. Model equation as follows:

$$COEt = \beta 0 + \beta 1RENt1 + \beta 2GDPt2 + et$$
$$RENt = \beta 0 + \beta 1COEt1 + \beta 2GDPt2 + et$$
$$GDPt = \beta 0 + \beta COEt1 + \beta 2RENt2 + et$$

Information:
COE = CO2 Emissions
REN = Renewable Energy
GDP = Economic Growth (in percent)
β = Konstanta
e = Error term
t = Time Period

Result and Discussion

The first step is to use the unit root test to see if the data is stationary. The purpose of this test is to make sure that the values of the variables are holding steady. Analyse table 1 using the unit root test

Table 1. Stationery Unit Root Test Result

Variable	Level		First Difference	
	Prob.	Description	Prob.	Description
COE	0.6491	Not Fulfil	0.0012	Fulfil
REN	0.0980	Not Fulfil	0.0000	Fulfil
GDP	0.0103	Fulfil	0.0000	Fulfil

According to the results of this analysis, there is no issue with data stationarity. At the initial difference and the level, all variables are at rest. Table 2 below shows the results of the optimal lag test:

Table 2. Lag Optimum Test

Lag	LogL.	LR	FPE	AIC	SC	HQ
0	-250.0400	NA	124205.9	20.24320	20.38946	20.28377
1	-219.7994	50.80426	22894.16	18.54395	19.12901*	18.70622
2	-206.1831	19.60745*	16433.98*	18.17465*	19.19850	18.45862*

Table 2, through the optimum lag test, the lag used is lag 2. Then cointegrating through the cointegration test to see the Vector Autoregressive (VAR) model is used, is shown in table 3.

Table 3. Cointegration Test

Hypothesized	Eigenvalue	Trace Statistic	0,05 Critical Value	Probability
None	0.413383	14.04177	29.79707	0.8383
At most 1	0.072777	1.773947	15.49471	0.9974
At most 2	0.001566	0.036047	3.841466	0.8494

Table 3 shows the results where there is no cointegration so that the VAR analysis is continued. VAR is shown in table 4 below:

Table 4. VAR Result

	COE	REN	GDP
COE(-1)	0.827917	8052.920	-9.780984
	(0.26951)	(7849.72)	(26.9174)
	[3.07194]	[1.02589]	[-0.36337]
COE(-2)	-0.032077	-3215.788	12.59897
	(0.26305)	(7661.61)	(26.2723)
	[-0.12194]	[-0.41973]	[0.47955]
REN(-1)	6.40E-06	0.165527	0.000188
	(7.1E-06)	(0.20686)	(0.00071)
	[0.90057]	[0.80018]	[0.26553]
REN(-2)	9.20E-06	0.134191	0.000225
	(7.0E-06)	(0.20280)	(0.00070)
	[1.32071]	[0.66169]	[0.32359]
GDP(-1)	-0.012178	113.6527	3.159914
	(0.00869)	(252.965)	(0.86744)
	[-1.40220]	[0.44928]	[3.64280]
GDP(-2)	0.000677	610.1515	-3.035381
	(0.00957)	(278.826)	(0.95612)
	[0.07069]	[2.18829]	[-3.17469]
C	0.131979	-4710.175	0.813976
	(0.10223)	(2977.44)	(10.2099)
	[1.29105]	[-1.58195]	[0.07972]

According to Table 4's results from the VAR test, REN(-1) is positively correlated with GDP, as indicated by a t-statistic of [0.26553]. The t-statistic [0.32359] also varies noticeably as REN(-2) or GDP increases or decreases. GDP(-1) is positively correlated with COE (t=-1.40220), and this correlation is statistically significant. GDP(-1) and REN both have a considerable impact on the t-statistic value [2.18829]. Increases in historical emissions have resulted in a promising upward trend in atmospheric carbon dioxide concentrations. However, historically, economic growth has been aided by the use of renewable energy. A favourable correlation will help in the development of a long-term economic system. The positive correlation between GDP and renewable energy use demonstrates the two-way nature of this connection. Historically, when GDP rises, emissions of carbon dioxide fall, proving that this practise has environmental benefits.

Table 5. Granger Causality Test Result

Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
GDP does not Granger Cause INF	22	2.34418	0.1262
INF does not Granger Cause GDP		1.48502	0.2544
UEM does not Granger Cause INF	22	10.3282	0.0012
INF does not Granger Cause UEM		0.91010	0.4212
UEM does not Granger Cause GDP	22	1.75143	0.2034
GDP does not Granger Cause UEM		1.62629	0.2258

Table 5 The direction of the causal link between variables requires a Granger causality test. The accompanying table shows that not all of the factors are causally related to one another.

Conclusion

releases of carbon dioxide have risen due to previous releases. However, historically, renewable energy use has contributed to economic expansion. As shown by GDP's positive association to usage of renewable energy, there is a bidirectional relationship between these two factors. The continued growth of renewable energy is something that should be encouraged through regulations that promote its use. Direct investment is one example of a macroeconomic policy that has to be supported and harmonised with energy efficiency programmes to ensure both economic development and environmental sustainability.

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