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Renewable energy consumption, CO_2 emissions, and economic growth: Evidence from Indonesia

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ABSTRACT

This study aims to examine the correlation between renewable energy, carbon dioxide emissions (CO_2), and economic development in Indonesia. This study uses a quantitative methodology, namely cointegration regression. This study uses data from 1980 to 2019. The findings show that renewable energy utilization has a negative impact on Indonesia's economic growth. This is because renewable energy generation is still constrained while the demand for renewable energy increases. Indonesia's economic growth has a favorable impact on CO2 emission levels. This is because fossil energy consumption is still very high in Indonesia. Energy use, in general, has a favorable impact on the national economy.

KEYWORDS

Renewable energy consumption; CO_2 emissions; economic growth

ARTICLE HISTORY

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1. Introduction

In recent decades, reliance on fossil fuels, such as oil, coal, and natural gas, has had a significant environmental impact, mainly due to the release of carbon dioxide (CO_2) into the atmosphere, contributing to global climate change. This presents a significant dilemma for countries worldwide as they strive to balance the imperative to achieve sustainable economic expansion and the responsibility to mitigate environmental consequences. Renewable energy is becoming increasingly seen as a viable solution in this context, as it cannot only reduce CO2 emissions but also stimulate economic development.

In Indonesia, renewable energy plays a vital role in the economy despite its low contribution to the Indonesian economy (Aswadi, 2023). Nugroho (2017) underlines

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the economic importance of renewable energy development, particularly in energy sustainability, economic development, and climate change mitigation. Furthermore, Tiawon (2023) emphasized the beneficial influence of green financing, energy efficiency, and renewable energy production on sustainable economic development, which includes economic growth and carbon emission mitigation.

The significant influence of economic growth on CO2 emissions is confirmed by Puspaningtyas (2022) and Idroes (2023). In addition, Idroes underlined the beneficial contribution of renewable energy consumption to mitigating these emissions. Wahyudi (2024) underlined the need for a sustainable energy policy, especially given Indonesia's underutilization of renewable energy.

However, the correlation between renewable energy, carbon dioxide emissions, and economic growth is complex. Renewable energy deployment requires considerable initial investment and often faces several technological and economic barriers. Moreover, the specific impact of switching to renewable energy on economic growth may differ based on each country's economic framework and government policies. This study aims to investigate the correlation between renewable energy, carbon dioxide emissions, and economic growth.

2. Literature review

2.1. Renewable energy consumption and economic growth

Extensive research continuously confirms a direct correlation between renewable energy consumption and economic growth promotion. Kasperowicz (2020) and Ntanos (2018) see a stable balance between the two factors over a prolonged period, with Kasperowicz highlighting the substantial contribution of renewable energy to economic development. Chen (2020) provides additional clarification on this connection, proposing that the impact of renewable energy consumption on economic growth is both positive and substantial in developing nations, significantly when they exceed a specific consumption threshold. Šimelytė (2017) expands on this conversation by examining the European Union, emphasizing the beneficial effects of renewable energy use on economic growth and export.

Furthermore, Koengkan (2020) has found a bidirectional relationship between renewable energy and economic growth in Mercosur countries. In contrast, in the US, Çevik (2020) did not find a direct causal relationship with its economic growth, having emphasized the potential benefits of renewable energy.

2.2. CO_2 emissions and economic growth

The relationship between CO2 emissions and economic growth is complex and varies across countries and periods. Niyonzima (2022) and Mardani (2019) found a positive long-term correlation between GDP and CO2 emissions, with the latter also highlighting a bidirectional causality. However, Sulaiman (2017) found that economic growth in Malaysia is not influenced by energy consumption or CO2 emissions. Chen (2020) suggested that urban economic growth can outpace carbon emissions, with the latter being influenced by the former. These findings underscore the need for context-specific policies to address the environmental impact of economic growth.

Exploring the relationship between CO2 emissions and economic growth further, Onofrei (2022) emphasized the importance of designing environmental policies to reduce emissions during periods of economic growth. The findings suggest that while economic growth can lead to increased CO2 emissions, the relationship is unclear and can be affected by various factors, including energy consumption and the type of growth. Furthermore, Chontanawat (2020) found a positive long-term correlation between CO2 emissions and economic growth.

3. Methodology

3.1. Data

Table 1 shows variable measurement with data from the World Bank's World Development Indicator (WDI) and Energy Information Administration (EIA), United States from 1995-2019.

Table 1. Variable Measurement

Variable	Description	Period	Source
lnGDP	Natural logarithm of Gross Domestic Product (constant 2015 US$)	1995-2019	WDI, World Bank
lnCO2	CO_2 emissions	1995-2019	WDI, World Bank
lnREC	Natural logarithm of Renewable Energy Consumption (BOE)	1995-2019	EIA, U.S

3.2. Model specification

Based on recent research, we modified the traditional neo-classical Cobb-Douglas production function by incorporating factors related to renewable energy consumption. Incorporating these factors into the production function can offer a more comprehensive understanding of the correlation between energy consumption and economic growth while mitigating the possible issue of omitted variable bias. The study's fundamental modeling formula is expressed as follows:

$$lnGDP_t = f(lnCO2_t, lnREC_t)$$

Where lnGDP is the natural logarithm of real GDP, lnCO2 is the natural logarithm of CO2 emissions, and energy consumption (lnREC is the natural logarithm of renewable energy consumption).

3.3. Econometric methodology

The analysis of the impact of renewable energy consumption and CO_2 emissions on Indonesia's economy is conducted in several phases. The first phase involves a pre-estimation process, beginning with a unit root test to determine the stationarity of the observed data. This is performed using the Augmented Dickey-Fuller (ADF) method. In the second phase, a cointegration test is applied to assess whether a long-term relationship exists between the dependent and independent variables, utilizing Johansen's cointegration approach. Finally, in the third phase, to enhance the reliability of the findings in evaluating long-term relationships, cointegration regression is conducted using the Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) methods (Elfaki et al., 2021; Mardhani et al., 2021).

4. Results and discussion

This section begins by explaining the descriptive statistics of the variables used in this study. The highest value of this variable is lnREC, and the smallest is lnLF. The lnREC variable has the highest data gap value, followed by the lnCO2 variable. From the probability values, lnGDP and lnCO2 have a probability below 1%. Based on the research model presented in the previous section, the first step that must be taken is to test the stationarity of the data. This test uses the Augmented Dickey-Fuller (ADF) method.

This section presents the long-term estimation results of the influence of renewable energy consumption, CO_2 emission and economic growth. Long-term

estimation results for renewable energy and non-renewable energy. Estimates from FMOLS results confirm the robustness of this study's results. The findings of this research show that two variables significantly influence economic growth, namely the CO_2 emissions and REC variables. The negative sign on the REC variable coefficient value indicates that renewable energy consumption in Indonesia is still low. The findings of this study determine that renewable energy has a negative and significant impact on Indonesia's economic growth.

5. Conclusion

A transition to renewable energy is also needed to achieve a better sustainable energy mix supporting sustainable energy supply and long-term sustainable economic growth in Indonesia. We examine the relationship between renewable energy consuion, CO2 emissions, andnomic grom 1995-2019 period. Using the cointegration regression estimation technique, the long-term dynamic relationship between renewable energy consumption negatively impacts economic growth due to its still low contribution compared to non-renewable energy.

Conflict of interest

The authors declare that they have no conflict of interest.

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