The relationship between renewable energy and sustainable development in Indonesia

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Abstract. This paper is conducted to examine the relationship between the use of renewable energy and FDI in Indonesia. The data used in this study is secondary data that has been published by the World Bank and accessed in www. Data.world bank.org periode 2004-2019. The data analysis method used is the autoregressive distributed lag (ARDL) method. The results of the study found that the use of renewable energy in the short and long term has a positive effect on Indonesia's economic growth. Meanwhile, the same thing is also shown from the FDI variable in the short term and long term which has a significant positive effect on economic growth and has a positive effect on economic growth. Finally, with this finding, it is concluded that both the short and long term the Indonesian government needs to make a breakthrough to explore renewable energy sources for economic growth.

1. Introduction
Economic growth is an important indicator for a country and is expected to increase in a certain period. In the globalization era, the economic growth of a country becomes very important and is used as a benchmark for the economic development of a country [1]. Economic growth is a picture of the economy that occurs in a country that is heading in a good direction for a certain period and is related to increasing production capacity, which is represented by national income [2].

Before the Covid-19 pandemic, Indonesia's economic growth grew quite well. Based on data from the Central Bureau of Statistics 2020, the economic growth of Indonesia grew by 2.07% [3], while in 2019, it grew 5.02% or slightly lower compared to 2018 by 5.17% [4]. Meanwhile, [5] in the second quarter of 2015, the lowest decline in economic growth was 4.74%, with the trade sector by 1.57% and hotels and restaurants 3.7%.

The increase and decrease in the economic growth of a country tend to experience a shift in the causal factors, although it cannot eliminate the classical factors themselves, namely macroeconomic variables, such as interest rates, exports, imports, inflation, currency exchange rates, and so on. The latest factors that affect economic growth are related to the environment, especially renewable energy consumption.
Many research related to economic growth and associated with the use of renewable energy found varied results. [6] Traditionally, there was a relationship between NRE and long-term economic growth in 38 developed countries. [7] There was a relationship between NRE consumption and economic growth in the Balkan and Black Sea Countries in the long run. [8] In developing countries, the use of non-EBT negatively affected economic growth. Meanwhile, in the long term, the use of NRE positively affected economic growth. [9] Research using MENA country data found that the use of NRE slightly affected economic growth. [10] Research using data from 11 MENA countries found that NRE and non-EBT on the country's economic growth, and there was a short-term and long-term relationship between the use of NRE and non-EBT on the country's economic growth.

[11] Research using data from 30 sub-Saharan African countries found that the relationship between NRE and non-EBT occurred in the long term rather than in the short term. [12] using panel data on countries that use the energy found that NRE consumption positively influenced economic growth. [13] Individually, the relationship between NRE and non-EBT on economic growth. However, heterogeneity and directional causality problems were found in the research model. [14] Research using data from 29 state organizations Economic Co-operation and Development (OECD) found a link between NRE and non-EBT on economic growth. [15] Research using data from 106 countries with different income levels found a causal and two-way relationship between energy consumption and economic growth. Meanwhile, [16] research in Turkey found that NRE did not affect economic growth while non-EBT significantly influenced economic growth. [17] Research using Malaysian data found both short and long-term NRE affected economic growth. Furthermore, [18] research using data from two MENA countries found that the use of NRE and non-EBT had a two-way relationship both in the short and long term on economic growth, but in the short term, the effect was negative.

Research [21] using Indian data indicated that foreign aid had a significant positive effect on economic growth in the long term. However, in the short term, foreign aid negatively affected economic growth. [22] Research in Nigeria found that direct investment macroeconomic were determinants of economic growth. [23] Using data from Japan and South Korea showed that direct investment did not affect gross domestic income in the long run.

[24] Research using data from Indonesia, Malaysia, and Thailand found that FDI has a significant effect on economic growth in Indonesia, Malaysia, and Thailand. [25] Another study found a causal relationship between foreign direct investment and economic growth in three ASEAN countries. Meanwhile, research conducted in Indonesia has mixed results. [26] found economic growth of Indonesia was closely related to direct investment both in the past and the present. [27] Using Indonesian data found that investment had a significant effect on economic growth. [28] and [29] where FDI had a positive effect on the economic growth of Indonesia.

Based on the description above, the results of empirical research in various countries, including the determining factors related to renewable energy use or foreign investment assistance, were still different in both the short and long term, and some were not significant. Thus, this study examined the effect of using renewable energy and foreign direct investment on economic growth.

2. Materials and methods
2.1. Data
This study used secondary data in the form of time-series data from renewable energy, foreign direct investment, and economic growth accessed on the official website of the World Bank (data.worldbank.org) from 2004 to 2019.

2.2. Research Model
This study used the Autoregressive Distributed Lag (ARDL) approach and used time-series data. ARDL model approach was initiated [30]. The ARDL model was carried out with the possibility of independent variables or explanatory variables that were not stationary. The use of ARDL produces consistent long-term coefficients [31]. On the other hand, the use of ARDL models becomes more useful in econometrics which makes economic theory from static to dynamic and takes into account
time [32]. And the ARDL approach can explain the response of the explanatory variable in the short and long term to changes in the dependent variable [33-35]. The ARDL model that can determine short-term and long-term responses can be formulated as follows: The model in distinguishing the long-term and short-term response periods by including the present and past values of explanatory variables is:

\[ \Delta Y_t = \alpha + \vartheta_1 Y_{t-1} + \cdots + \vartheta_p Y_{t-p} + \beta_0 X_t + \beta_1 X_{t-1} + \cdots + \beta_q X_{t-q} + \varepsilon_t, \]  
\[ \Delta P_t = \beta_0 + \alpha_1 \Delta REC_{t-1} + \alpha_2 \Delta FDI_{t-1} + \varepsilon_t, \]

then the empirical model:

\[ \Delta Y_t = \alpha + \vartheta_1 Y_{t-1} + \cdots + \vartheta_p Y_{t-p} + \beta_0 X_t + \beta_1 X_{t-1} + \cdots + \beta_q X_{t-q} + \varepsilon_t, \]  
\[ \Delta P_t = \beta_0 + \alpha_1 \Delta REC_{t-1} + \alpha_2 \Delta FDI_{t-1} + \varepsilon_t, \]

Where: EG is the dependent variable (economic growth), REC and FDI are independent variables (renewable energy consumption and foreign direct investment), \( \beta_0 \) is a constant, \( \Delta \) is the parameter for the autoregressive model, \( \Delta \) is the difference, \( \varepsilon_t \) error value, and \( t \) is the period.

3. Results and discussion

3.1. Data description and classical assumption tests

This section describes the data description and classical assumption test of each variable used in the study (Table 1). Based on Table 1 above, the average economic growth was 5.45%, and the minimum value was 4.60% in 2009, and the maximum value was 6.30% in 2007. The average percentage of direct investment flowing into Indonesia is 1.87%, with a maximum of 2.90% and a minimum of 0.50%. The average percentage of direct investment flowing into Indonesia is 1.87%, with a maximum of 2.90% and a minimum of 0.50%.

Table 1. Data description and classical assumption tests

| Descriptive | EG (%) | REC_% | FDI % |
|-------------|--------|-------|-------|
| Mean        | 5.45   | 38.72 | 1.87  |
| Median      | 5.35   | 38.20 | 2.00  |
| Maximum     | 6.30   | 41.40 | 2.90  |
| Minimum     | 4.60   | 36.90 | 0.50  |
| Std. Deviation | 0.55   | 1.42  | 0.72  |

Classical assumption tests

| Normality tests |   |
|-----------------|---|
| Jarque-Bera     | 1.04 |
| Probability     | 0.59 |

Autocorrelation test | Breush Godfrey LM Test | Obs-R\(^2\) = 0.70
Heteroscedastisity test | Breush Pagan Godfrey | Obs-R\(^2\) = 2.90

Furthermore, Table 1 above explained that the data used did not have deviations where the standard deviation value was lower than the average value. Based on the normality test, the data was normally distributed based on the Jarque-Bera value of 1.04 and the probability value of 0.59 or insignificant at 5%.

3.2. Stationarity and co-integration tests

This section describes the results of the stationarity and cointegration tests. The data stationarity test was carried out using the Dickey and Fuller-ADF and Phillips Perron-P.P. (Table 2) below:
Table 2. Stationarity and Cointegration Tests

| Variables | Stasionerity test/ Unit Root tests | Decision |
|-----------|------------------------------------|----------|
|           | Dickey and Fuller-ADF 1979         |          |
|           | Intercept Level 1stDifferences Level 1stDifferences |          |
| EG        | 0.0870* 0.01**** 0.07* 0.15 | -        |
| REC       | 0.4718 0.00**** 0.98 0.02** | -        |
| FDI       | 0.0041*** 0.00**** 0.02** 0.00*** | -        |

| Variables | Phillips Perron-P-P Tests |          |
|-----------|---------------------------|----------|
|           | Intercept Level 1stDifferences Level 1stDifferences |          |
| EG        | 0.08* 0.00**** 0.00*** 0.00*** | -        |
| REC       | 0.04** 0.03** 0.85 0.00*** | -        |
| FDI       | 0.00*** 0.00**** 0.02** 0.00*** | -        |

| Co-integration Tests | F- Statistics Bounds Test Co-integration results |
|----------------------|-----------------------------------------------|
| F-statistic          | Value | Signif. | I(0) | I(1) |
|                      | 2.8245 | 5% | 3.79 | 4.85 |
|                      |       | 2.5% | 4.41 | 5.52 |
|                      |       | 1%   | 5.15 | 6.36 |

Based on Table 2 above, the results of the two tests showed that all variables used were not stationary at the level, but stationary at 1stDifferences with a significant variable value of 1% in 1stDifferences for the intercept model with the ADF test and trend and intercept with the P-P test. After analyzing the stationarity test of each variable, then the co-integration test of each tested variable was carried out by taking into account the f-statistics and f-critical, including the upper and lower limits at the significance level of 1%, 2.5%, 5%, and 10%. The test results showed that the f-statistics value was 2.82 with a lower limit value of 3.17 and an upper limit of 5.15, meaning that the limit value of the two limits was higher than the value of the f-statistics.

3.3. ARDL Regression Estimation

After discussing the data stationarity test and cointegration test, and then it discussed the results conducted with ARDL (Table 3). Based on the ARDL tests, renewable energy use significantly influenced the economic growth of Indonesia in the short and long term. The models were 2 and 1. In that model, all of the REC variables had a significant effect with a probability of 5% and 1% on economic growth, but FDI had no significant effect on economic growth.

Table 3. ARDL Regression Estimation Results

| Panel A. EG Dependent | Panel B. EG Dependent | Panel C. EG Dependent |
|-----------------------|-----------------------|-----------------------|
| ARDL                  | Short-term ARDL       | Long-term ARDL        |
| Var.                  | Coeff.                | t-stat.               | Var.                  | Coeff.                | t-stat.               | Var.                  | Coeff.                | t-stat.               |
| EG(-1)                | 0.0008                | 0.0029                | Var.                  | 0.4981*               | 2.1196*               | Var.                  | 0.3145                | 2.7459**              |
| REC                   | 0.4981*               | 2.1196*               | D(REC)                | 0.4981                | 2.1196*               | REC                   | 0.3661                | 1.9376*               |
| REC(-1)               | -0.6429**             | -2.6983               | D(REC(-1))            | -0.4590**             | -2.6918**             | FDI                   | 0.3658                | 1.7932                |
| REC(-2)               | 0.4590**              | 2.6918                | CointEq(-1)           | 0.3658                | 1.7932                | C                    | -7.3310               | -1.6279               |
| FDI                   | 0.3658                | 1.7932                |                         |                       |                       |                       |                       |                       |
| C                     | -7.3251               | -1.4610               |                         |                       |                       |                       |                       |                       |
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5

R2 0.6845
Adj. R2 0.4873
F test 3.4719**

Level of significant: (*) (**); (***)=10%; 5% ; 1%;

In addition, the results of the f-test obtained a value of 3.4719 and a significant 5%. In other words, the use of renewable energy and foreign direct investment significantly influenced economic growth. Furthermore, the value of the coefficient of determination-R2 was 0.6845 or 68.45%. It indicated that the ability of renewable energy use and foreign direct investment could explain the economic growth of Indonesia 68.45%, and the rest was influenced by other variables outside of this study.

On the other hand, the short-term ARDL test results showed that renewable energy significantly influenced economic growth. The Co-int value had a negative coefficient of 0.9991 and a significant 1% of the short-term ARDL estimation results. It indicated that the ARDL model used was fit and reliable. So, it indicated that there was a potential relationship in the long term from renewable energy use and foreign direct investment to economic growth. Based on Table 3 above, the renewable energy use had a coefficient of 0.3145 and a significant 5%, meaning that the higher renewable energy use will increase economic growth in the long term. This finding was alike with the research findings [18]; [17] and [10], which concluded that the use of renewable energy affected the economic growth of a country both in the short and long term. Furthermore, foreign direct investment had a coefficient of 0.3661 with a significance of 10%. It revealed that direct investment in the long term affected economic growth. This finding is in line with research [2] in India; [24]; [25] in three ASEAN countries; and in Indonesia [26], [28, 29] which stated that direct investment affected economic growth.

Based on the results above, the use of renewable energy was a very substantial variable in increasing the economic growth of a country, both in the short and long term. Meanwhile, assistance in foreign direct investment received by a country only contributed in the long term. Thus, it indicated that the use of renewable energy was a necessity for the economic growth of Indonesia compared to direct investment.

4. Conclusions
This research found that the use of renewable energy and foreign investment both positively and significantly influenced economic growth in both the short and long term. However, this study has weaknesses in the timeframe used. In addition, it is also necessary to add other energy source variables and other factors variables that can strengthen the results of the research.

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