The effect of CO₂ emissions in Indonesia

Z Yusuf¹, Wardhiah², G Syamni²*, M J A Siregar³, Y A Sitepu³

¹Accountant Department, Universitas Malikussaleh, Jalan Cot Tgk. Reuleut Muara Batu, Po. Box 141, Aceh Utara, Indonesia
²Management Department, Universitas Malikussaleh, Jalan Cot Tgk. Reuleut Muara Batu, Po. Box 141, Aceh Utara, Indonesia and Student in Doctorate Program in Management, Universitas Syiah Kuala, Darussalam-Banda Aceh 23111, Indonesia
³Student in Department Management, Universitas Malikussaleh, Jalan Cot Tgk. Reuleut Muara Batu, Po. Box 141, Aceh Utara, Indonesia.

*Email: ghazali.syamni@unimal.ac.id

Abstract. This study was conducted to examine the effect of the variable use of CO₂ emission gas and export variables on Indonesia's economic growth. The data used in this study are time series data from the two variables for the period 2004 to 2019. All data were obtained from the world bank and accessed through the www.data.world bank.org. The data analysis method used in this study uses an autoregressive distributed lag (ARDL) model approach. The ARDL model is used to examine the short-term and long-term effects of CO₂ gas emission variables and export variables. The results of the study found that the variable use of CO₂ emission gas in the short term had a positive and insignificant effect on economic growth. The export variable has a significant positive effect on economic growth. Meanwhile, in the long term, the variable use of CO₂ emission gas and the export variable has no effect on Indonesia's economic growth. This finding shows that Indonesia's economic growth is still determined by exports, but in the long term the government must work harder to increase its exports. In addition, export activities must not lead to the use of excessive CO₂ emissions.

1. Introduction
Research in Indonesia related to economic growth mostly tends to analyze using macroeconomic variables. [1-5] but many research in many countries have pointed to the source of energy factors influencing economic growth in various countries. So it is suggested that policymakers are encouraged to focus on exploring new environmentally friendly energy sources [6].

Two groups of energy sources; non-renewable energy (fossil mining) and renewable energy sources. Although the two energy sources still do not have an agreement on economic growth [7, 8]. However, studies [9, 10] mentioned that energy use increased economic growth in various countries. The effect of using non-renewable energy is to increase the use of CO₂ gas emissions. CO₂ gas emission is a gas produced from all human activities and in its development is more determined by the contribution of energy use to industrial progress. Several studies conducted in testing CO₂ gas emissions...
emissions use to increase economic growth have found inconsistent results. [11] Based on data from developing and developed countries from the G20 countries, there was a relationship between CO2 gas emissions use and renewable energy use with economic growth. [12] The study using data from MENA countries found that renewable energy use had little effect on economic growth, but CO2 emissions consumption tends to be higher on economic growth. The opinions of the two researchers above were supported, [13] who suggested that the government should make regulations directed at the hydrocarbon sector as a source for economic refreshment that leads to the use of low carbon for financial efficiency.

A study using Iranian data found the effect of CO2 gas emissions use and energy production in long-term economic growth using data from Greece and Bulgaria found that in the long term, there was a causality of the use of CO2 emissions to economic growth [14,15]. Meanwhile, [16] the study data from developed and developing countries group found that the use of gas emissions increased the energy consumption, thereby increasing energy growth, except for MENA countries, where the MENA countries experienced a decline in economic growth [17] There was a one-sided causality relationship between the use of carbon gas emissions and economic growth for countries that did not export oil in the short term and long term for countries that export oil with bilateral relations. [18] There was a negative relationship between economic growth and carbon emissions in the long term.

In addition, the use of CO2 gas emissions for economic growth in a country cannot be separated from macroeconomic variables. One of the macroeconomic variables is exports. High export capabilities countries allow for increased economic growth because they have sufficient resources, and then, they exchange with exports and get some money for exports. Therefore, exports are crucial for the sustainability of economic growth in any country [19].

Several empirical studies have found that exports affected economic growth in various ways. [20] Research in Malaysia found that exports were related to reciprocal economic growth. [21] In the long term, exports were negatively related to economic growth in Sri Lanka. [22] Exports could boost economic growth in the long term in Oman. [23] In Bangladesh, exports only affected economic growth in one direction, not in two directions.

Research in ASEAN and Indonesia [2] revealed no interrelated relationship between exports and economic growth in the three ASEAN countries. [5] Exports had a relationship with economic growth in the three ASEAN countries. [24] Said exports as a crucial determinant of economic growth.

The background description above showed different research results on the relationship between the explanatory and the dependent variables used in this research. These differences were in terms of direction, duration, and causality, so they need to be studied to obtain further results. Thus, this research examined the effects of CO emissions and the level of exports on economic growth in Indonesia.

2. Materials and methods

2.1 Data

This study used annual monthly data from 2004 to 2019 from world bank institutions accessed on www.data.worldbank. The data were taken from the institution because the institution has been trusted by the government and even the world in issuing financial data, exports, gas emissions, and economic growth.

2.2 Data Analysis Methods

Because it used time-series data, this research analyzed the data using the Autoregressive Distributed Lag approach. In the Autoregressive Distributed Lag model, there are several steps before testing. First, performing Stationary tests using the Augmented Dickey-Fuller Test-ADF and Phillips Perron-P.P Test to determine whether the time-series data contained unit-roots or not. Second, performing a cointegration test to know whether there is a long-term relationship between variables from the Autoregressive Distributed Lag model using the Johansen System Co-integration (JSC), and the last step was estimating the Autoregressive Distributed Lag model both in the short and long term.
3. Results and discussion

3.1 Data Description and Classical Assumption Tests

The initial part of the regression results explained the results of the data description and the classical assumption diagnostic tests results, both short and long-term estimates in (Table 1) below.

| Table 1. Data Description and Classical Assumption Tests |
|--------------------------------------------------------|
| **Descriptive** | **EG (%)** | **CO₂ (KT)** | **EXPORT ($)** |
| Mean | 5.46 | 430.205,1 | 195.437.136.877,4 |
| Median | 5.32 | 416.560,2 | 203.008.815.789,6 |
| Maximum | 6.30 | 563.324,5 | 251.593.056.456,2 |
| Minimum | 4.60 | 337.635,4 | 116.214.735.602,7 |
| Std. Dev. | 0.58 | 80.771,6 | 44.432.841.496,9 |

**Classical assumption tests**

| Normality tests | Jarque-Bera | 4.1261 |
|-----------------|-------------|--------|
| Probability     | 0.1270      |

**Autocorrelation test**

| Breush Godfrey LM Test | Obs-R² = 12.2273*** |

**Heteroscedasticity test**

| Breush Pagan Godfrey | Obs-R² = 5.6875 |

Based on Table 1 above, the average economic growth of Indonesia was 5.46 or 5.46 %, with the highest value in 2007 being 6.30 % and the lowest 4.60 in 2009. Furthermore, the average use of emissions was 430.205.1 kilotons, with the highest use of 563.324.5 kilo tons in 2016, and the lowest was 337,634.5 kilo tons in 2004. Meanwhile, the export level during the research period was an average of 195,437,136,877.4 US dollars, wherein in 2018, the highest export value was 251,593,056,456.2 US dollars, and the lowest was 116,214,735,602.7 US dollars in 2004. On the other hand, the data can be used for regression testing because the data was normal. It was indicated by the value of Jarque-Bera 4.1261, which was not significant at the 5% level. However, this research model was not free from the problem of autocorrelation tested by the Breush Godfrey LM Test, where the value of Obs-R² = 12.2273 which was 1% significant but free from heteroscedasticity problems because the value of Obs-R² = 5.6875, which was insignificant at 5%.

3.2. Stationarity and Cointegration Tests

This section describes part of the first ARDL testing step, namely data stationarity detection based on the Dickey and Fuller-ADF 1979 and Phillips Perron-P.P Test (1988). The results of the two tests determined the existence of the unit root data in the position of first differences or levels. After the stationarity test, the cointegration test was carried out (Table 2).

| Table 2. Stationarity and Cointegration Tests |
|-----------------------------------------------|
| **Dickey and Fuller-ADF 1979**               |
| Variables | Intercept | Trend and Intercept | Decision |
|-------------|------------|---------------------|---------|
| Level       | 1stDifferences | Level | 1stDifferences |         |
| EG          | 0.0870*   | 0.0019***       | 0.0707* | 0.1544 | 1stDifferences |
| CO₂         | 0.7789    | 0.0015***       | 0.3316  | 0.0095*** | 1stDifferences |
| EXP         | 0.1406    | 0.0100***       | 0.2857  | 0.1365 | 1stDifferences |
| **Phillips Perron-P.P Test**                |
| Variables | Intercept | Trend and Intercept |         |
|-------------|------------|---------------------|---------|
| Level       | 1stDifferences | Level | 1stDifferences |         |
| EG          | 0.0870*   | 0.0000***       | 0.0071*** | 0.0000*** | 1stDifferences |
| CO₂         | 0.8670    | 0.0017***       | 0.3726  | 0.0133** | 1stDifferences |
| EXP         | 0.00118***| 0.0057***       | 0.2099  | 0.0002*** | 1stDifferences |

Co-integration test

F- Statistic bounds test co-integration results
Based on Table 2, the results of the Dickey and Fuller-ADF test variables used in the study were stationary at 1st Differences with an intercept that can be seen from a significance value of 1% but not with a trend and intercept.

Meanwhile, at the level, this research variable did not have a stationary value of 1%. In the Phillips Perron-P.P Test, the data has been stationary at first differences with either intercept or trend and intercept. After explaining the stationarity test results, and then it explained the cointegration test results between the independent variables used in this study. Based on Table 2 above, the Cointegration test section explained the respective f-statistics and f-critical values at the significance level of 1%, 2.5%, 5%, and 10%. The f-critical value consists of the f-critical upper and lower limits.

Cointegration test results obtained f-statistic value 1.5251 and lower limit value 3.17 and upper limit 4.14. So, it concluded that the data used in this research variable did not have a cointegration value. It revealed no long and short-term relationships between the explanatory variables; CO2 and Exports, with the dependent variable being economic growth.

### 3.3. ARDL Regression Estimation

This section explains the results of ARDL Regression Estimation in both the short and long term (Table 3). Table 3 above describes that the ARDL estimation uses models 2, 2, and 2. Overall, the two independent variables significantly affected economic growth with the f-statistic value of 9,858 with a significant level of 5%. Then, the value of R2 was 0.94% or 94%, which indicated that the ability to export and use CO2 emissions could explain the economic growth of 94%, and the rest was influenced by other variables not included in this study.

Table 3 presents the short-term and long-term ARDL test results. In the short-term ARDL test, the Co-intEq(-1) value was negative 0.331 or insignificant. The CointEq(-1) variable was defined as the error correction variable from the ARDL model used. The insignificance of the Co-intEq(-1) variable indicated that the ARDL model used in this study was potentially less reliable.

| Table 3. ARDL Estimation |
|---------------------------|
| **EG Dependent** | **EG Dependent** | **EG Dependent** |
| ARDL | Short-Term ARDL | Long-Term ARDL |

| Var. | Coeff. | t-stat. | Var. | Coeff. | t-stat. | Var. | Coeff. | t-stat. |
|------|--------|--------|------|--------|--------|------|--------|--------|
| EG(-1) | -0.004 | -0.018 | D(EG(-1)) | -0.672 | -3.688** | C02 | -3.558 | -0.927 |
| EG(-2) | 0.672 | 3.688*** | D(LN_CO2) | 0.683 | 0.829 | EXP | 4.159 | 1.008 |
| C02 | 0.6837 | 0.829 | D(LN_CO2(-1)) | 2.138 | 2.190* | C | -58.646 | -0.897 |
| C02(-1) | 0.2738 | 0.361 | D(LN_EXP) | 10.994 | 6.118*** | EXP | 4.159 | 1.008 |
| C02(-2) | -2.138 | -2.190* | D(LN_EXP(-1)) | 2.764 | 1.458 |
| EXP | 10.994 | 6.118*** | CointEq(-1) | -0.331 | -1.600 |
| EXP(-1) | -6.849 | -3.555** |
| EXP(-2) | -2.764 | -1.458 |
| C | -19.468 | -1.1557 |
| R² | 0.940 | |
| Adj. R² | 0.844 | |
| F test | 9.858** | |

Long-term equation: EC = EG - (-3.5590*C02_EMISSION + 4.1598*EXPORT -58.6468 )
Furthermore, in table 3, direct, short-term, and long-term tests were also carried out, which found that CO2 emission gas significantly influenced economic growth at lag 2 (CO2(-2)) with a significant level of 10%. In the short term, CO2 emission gas affected economic growth at D(LN_CO2(-1)) with a significance level of 10%. This finding is in line with the previous research[12],[11], and [14], which stated that the consumption of CO2 emission gases affected economic growth. It indicated that during the period, the data used still contributes to economic growth in Indonesia. But in the long-term, the use of CO2 gas emissions can reduce economic growth despite insignificant results because the use of CO2 gas emissions in the long-term and excessive can cause environmental damage and lead to a decrease in a country's economic growth.

Furthermore, the export significantly influenced economic growth on the EXP and EXP (-1) with a significance level of 1% and 5%. Also, in the short term, the exports significantly influenced economic growth D(LN_EXP) with a significance level of 1%. This finding is in line with the research conducted [5]; [23] and [24], which mentioned that exports affected economic growth. This finding indicated that exports were the biggest contributor to economic growth but must be selective, not to cause environmental disturbances.

4. Conclusions
This research examined the effect of the use of carbon emission gas (CO2) and exports on the economic growth in Indonesia. This research found that economic growth in Indonesia in the short term was more determined by the export than carbon emissions use. However, in the long-term, it found a negative direction for the use of carbon emission gases. This finding indicated that the use of carbon emissions in the long-term potentially reduced the economic growth of a country (Indonesia). The decline in economic growth was caused by environmental damage due to the excessive use of carbon gas emissions. This research had weaknesses because the independent variables used were only two, and the period was not longitudinal. In addition, there were problems related to autocorrelation and the possibility of an unstable ARDL model. In the future, it needs to use other models or methods, such as error correction models or causality testing.

Acknowledgments
The researcher would like to thank those who have helped in this research so that this research is perfect. The researcher is also grateful to the Faculty of Economics and Business, Malikussaleh University, and the Malikussaleh University Research and Community Service Institute so that this research can be carried out.

References
[1] Syamni G, Fahmi A, Siregar W F 2018 Foreign direct investment, portfolio investment, and economic growth in Indonesia: Vector Auto Regression Approach. Human Falah: Jurnal Ekonomi dan Bisnis Islam,5 (1), 1-13.
[2] Andriga and Indraswari I 2019 Analisis kausalitas antara investasi asing langsung dan ekspor dengan pertumbuhan ekonomi: Studi kasus Malaysia, Thailand dan Indonesia. Majalah Ilmiah Manajemen, 9 (02), 28-37.
[3] Arifin, Y. (2016). Pengaruh harga minyak dunia, nilai tukar dan inflasi terhadap pertumbuhan ekonomi Indonesia. Economics Development Analysis Journal, 5(4), 474-483.
[4] Septiawan, D. A., Hidayat, R. R., & Sulismiyati, S. (2016). Pengaruh Harga Minyak Dunia, Inflasi, dan Nilai Tukar Terhadap Pertumbuhan Ekonomi Indonesia (Studi Pada Tahun 2007-2014). Jurnal Administrasi Bisnis, 40(2), 130-138.
[5] Shopia A and Sulismiyati S 2018 Pengaruh foreign direct investment, ekspor, dan utang luar negeri terhadap pertumbuhan ekonomi Asean (Studi pada Produk Domestik Bruto Indonesia, Malaysia, dan Thailand Periode Tahun 2007–2016). Jurnal Administrasi Bisnis, 61(3), 20-28.
[6] Haseeb M, Abidin I. S. Z, Hye, Q M A and Hartani N H 2019 The impact of renewable energy
on economic well-being of Malaysia: Fresh evidence from auto regressive distributed lag bound testing approach. *International Journal of Energy Economics and Policy*, 9(1), 269.

[7] Kahia M, Aïssa, M S B, and Lanouar C 2017. Renewable and non-renewable energy use-economic growth nexus: The case of MENA Net Oil Importing Countries. *Renewable and Sustainable Energy Reviews*, 71, 127-140.

[8] Zafar M. W, Shahbaz, M, Hou, F, and Sinha A 2019 From nonrenewable to renewable energy and its impact on economic growth: the role of research & development expenditures in Asia-Pacific Economic Cooperation countries. *Journal of Cleaner Production*, 212, 1166-1178.

[9] Bhattacharyya M, Paramati S. R, Ozturk I, and Bhattacharya, S 2016 The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. *Applied Energy*, 162, 733-741.

[10] Foxon, T. J. (2017). *Energy and Economic Growth: Why we need a new pathway to prosperity*. Routledge.

[11] Paramati, S. R., Mo, D., & Gupta, R. (2017). The effects of stock market growth and renewable energy use on CO2 emissions: evidence from G20 countries. *Energy Economics*, 66, 360-371.

[12] Charfeddine L, and Kahia M 2019 Impact of renewable energy consumption and financial development on CO2 emissions and economic growth in the MENA region: A panel vector autoregressive (PVAR) analysis. *Renewable energy*, 139, 198-213.

[13] Abueid, R. (2020). Impact of Macroeconomic Variables on the Economic Growth in the Middle East Countries. *Journal of Applied Economic Sciences (JAES)*, 15(69), 594-604.

[14] Ahmad, N., & Du, L. (2017). Effects of energy production and CO2 emissions on economic growth in Iran: ARDL approach. *Energy*, 123, 521-537.

[15] Obradović, S., & Lojanica, N. (2017). Energy use, CO2 emissions and economic growth–causality on a sample of SEE countries. *Economic research-Ekonomska istraživanja*, 30(1), 511-526.

[16] Muhammad, B. (2019). Energy consumption, CO2 emissions and economic growth in developed, emerging and Middle East and North Africa countries. *Energy*, 179, 232-245.

[17] Mensah, I. A., Sun, M., Gao, C., Omari-Sasu, A. Y., Zhu, D., Ampimah, B. C., & Quarcoo, A. (2019). Analysis on the nexus of economic growth, fossil fuel energy consumption, CO2 emissions and oil price in Africa based on a PMG panel ARDL approach. *Journal of Cleaner Production*, 228, 161-174.

[18] Gökmenoğlu, K., & Taspinar, N. (2016). The relationship between CO2 emissions, energy consumption, economic growth and FDI: the case of Turkey. *The Journal of International Trade & Economic Development*, 25(5), 706-723.

[19] Ali, B. J., Hasan, H., & Oudat, M. S. (2021). Relationship Among Export, Import and Economic Growth: Using Co-Integration Analysis. *Psychology and Education Journal*, 58(1), 5126-5134.

[20] Abdullah, D. N. C., Shaari, M. S., & Hussain, N. E. (2017). Investigating the Causal Relationship between Export and Economic Growth: A Malaysian Perspective. *International Journal of Academic Research in Business and Social Sciences*, 7(7), 2222-6990.

[21] Sultanuzzaman, M. R., Fan, H., Akash, M., Wang, B., & Shakij, U. S. M. (2018). The role of FDI inflows and export on economic growth in Sri Lanka: An ARDL approach. *Cogent Economics & Finance*, 6(1), 1518116.

[22] Khan, A. M., and Khan, U. (2021). The Stimulus of Export and Import Performance on Economic Growth in Oman. *ELIT–Economic Laboratory for Transition Research Dz. Washington* 4/5, 17(3), 71.

[23] Kibria, M. G., & Hossain, M. S. (2020). Does export affect the Economic growth?: An empirical investigation for Bangladesh. *American Journal of Economics and Business Management*, 3(1), 219-226.

[24] Prawira B, Sarfiah S. N, and Jalunggono G 2019 Pengaruh foreign direct investment (FDI), ekspor dan impor terhadap pertumbuhan ekonomi Indonesia 1998-2017. *Dinamic: Directory Journal of Economic*, 1(1), 1-10.