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Article

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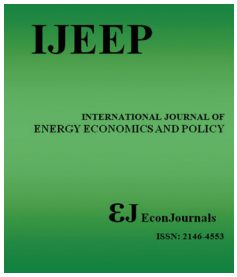

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The Dynamic Effects of Tourists and Tourism on Carbon Emissions in Indonesia

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ABSTRACT

This study examines the short-and long-run effects of expenditure, tourists, the tourism sector, and AVTUR on the carbon emissions in Indonesia. The quarterly data are used to estimate the autoregressive distributed lag model in the study. The results show that in the short-run expenditure, tourists and AVTUR have positive and significant effects, while the tourism sector has adverse and significant effects on carbon emissions. Furthermore, in the long run, only AVTUR has positive and significant effects on carbon emissions, and other variables have adverse and significant effects. Policymakers should encourage friendly tourism to protect environmental quality and achieve optimal economic contributions.

Keywords: Tourism, Carbon Emissions, AVTUR, Expenditure
JEL Classifications: Q30, Q50, Z30, Z32

1. INTRODUCTION

Sustainable International Travel (2024) reports that tourism contributes 8% of the world's carbon emissions. It is further reported that the most significant contribution comes from transportation at 49%, followed by goods at 12% and foods and beverages at 10%. There are still other activities related to tourism that contribute to carbon emissions, such as agriculture and services, each at 8%. These data prove that tourism has a very significant role in carbon emissions, so further analysis is needed to determine whether tourism negatively impacts environmental quality. This is also proven by empirical evidence, most of these studies find that tourism hurts environmental quality because of increased carbon emissions.

Many studies have been conducted in many countries using various models. Koçak et al. (2020), for example, analyzed the influence of tourism on climate change in 10 countries that tourists widely visit. The results of the study found that tourism activities have an effect on increasing emissions in these countries. This is a dilemma because many countries hope for tourism as one of the sectors of economic growth and foreign exchange reserves. Research with the ARDL nonlinear model also provides other empirical evidence that tourism activities increase carbon emissions in Pakistan in the long term (Rehman et al., 2021).

Furthermore, Handoyo et al. (2022) documented the influence of several variables on carbon emissions, such as foreign direct investment (FDI), tourism, and trade on carbon emissions. The study divided the countries into different income groups, ranging from high-income, middle-income, and low-income countries. The study results prove that tourism contributes to the increase in carbon emissions in high-income countries, which is higher than in other groups of countries. The results of this study are

confirmed by a study conducted by Arslan et al. (2023), which also divided countries based on income groups in 102 countries. Other empirical aspects in a review of 81 studies also confirm that tourism affects carbon emissions conducted by Sun et al. (2022).

Raihan and Tuspekova (2022) used the dynamic OLS model to analyze tourism's effect on Singapore's carbon emissions. The study's results also provided the same result, namely that tourism has a positive effect on carbon emissions. Singapore is a very small country, so an increase in carbon emissions could have a very significant effect on environmental quality. Therefore, it is necessary to be careful when managing tourism in the country to control environmental quality.

The increase in carbon emissions related to tourism is not only in terms of the number of tourists who come, which causes an increase in carbon emissions but also in several variables related to tourism that also affect carbon emissions. For example, Yıldırım et al. (2023) documented the effect of tourist spending on carbon emissions. The results of this study prove that tourist spending has a positive and significant effect on carbon emissions. Furthermore, Wang and Xi (2023) found that fuel affects carbon emissions in Europe because the increase in fuel prices has a negative effect on the number of tourists, so carbon emissions from these activities do not increase.

Tourism activities also affect the increase in waste, so carbon emissions from waste also increase. Bhuiyan et al. (2024) proved that the amount of waste increased significantly with the increasing number of tourists visiting the location of tourism. This condition results in a decrease in environmental quality due to tourism activities. The decrease in environmental quality in the next period will certainly affect tourism because the number of tourists will decrease with low environmental quality. This means that tourism and environmental quality have an influence that can be bidirectional. This study is in line with the study research conducted by Jong et al. (2022), which found that a decrease in environmental quality resulted in a decrease in the number of tourists.

Many studies have been conducted, and all of them confirm that tourism affects increasing carbon emissions in many countries. However, Tian et al. (2021) provide empirical evidence to the contrary. The results of their study provide evidence that increasing tourism has a negative effect on carbon emissions in the G20-the increase in tourists results in a decrease in carbon emissions in the long term. The results of this study provide a different prospect that tourism could have a negative effect on carbon emissions.

Thus, the results of previous studies have yet to provide a consensus on whether tourism has a positive or negative effect on carbon emissions. Based on these conditions, this study will provide other contributions on whether tourism has a positive or negative effect on carbon emissions in Indonesia. This study is critical because Indonesia makes the tourism sector one of the sources of economic growth in Indonesia. The results of this study will provide a basis for policymakers in managing and developing the tourism sector in Indonesia.

2. LITERATURE REVIEW

Tourism research is fundamental because countries are trying to increase the tourism sector's role as a source of economic growth. This is reasonable because the tourism sector has extensive backward and forward linkages. The progress of the tourism sector will affect the progress of many other related sectors. However, the tourism sector also has a very significant influence on carbon emissions. Many studies in many countries have proved this. Some of these researchers include Koçak et al. (2020), who analyzed the effect of tourism on carbon emissions in 10 countries, revealing that tourism had a positive and significant effect on carbon emissions. The results of this study are a tough choice in encouraging the development of the tourism sector because it will have a negative impact on environmental quality.

The same results were also shown in a study conducted by Rehman et al. (2021) using the ARDL nonlinear approach, showing that tourism positively and significantly affects carbon emissions. Other cases also provide relatively similar results from a study conducted by Handoyo et al. (2022). The study also included several other variables, such as FDI trade and the tourism sector. This study was conducted by dividing groups of countries according to income level classification. The influence of tourism on carbon emissions is more significant in high-income countries than in middle and low-income countries. A study of the influence of tourism on carbon emissions based on income classification was also conducted by Arslan et al. (2023) in 102 countries, and the study's results proved that the influence of tourism is more significant in countries with high incomes.

Sun et al. (2022) also found other empirical evidence by reviewing the influence of tourism on carbon emissions. The review's results showed that all papers showed tourism's positive and significant influence on carbon emissions. This is another confirmation that strengthens the empirical evidence of the influence of tourism on carbon emissions.

The influence of tourism on carbon emissions is not only in large countries but also in small countries like Singapore. This is based on a study conducted by Raihan and Tuspekova (2022) using the dynamic OLS approach. This condition is very concerning because the progress of tourism has a negative impact on environmental quality. Small countries like Singapore will have a more significant influence because the country is small, but the number of tourists visiting the country is huge.

Other research results with relatively similar empirical findings were conducted by several other researchers, such as Raihan et al. (2023), who conducted research in Egypt, Kuldasheva et al. (2023), and Kumail et al. (2024). The influence of tourism on carbon emissions has a different development, where in the initial stage, there is a decrease in carbon emissions and an increase in the next stage. This is based on a study by Zhao et al. (2024). These results provide a different perspective because of the different forms of development. Relatively similar results were also found by Purwono et al. (2024). The results of this study provide an N-shaped form of the influence of tourism on carbon emissions.

There is a decrease in carbon emissions in the initial stage, but it increases in the next stage.

Several other researchers, such as the influence of tourist expenditure on carbon emissions, also conducted other analyses. The study was conducted by Kuldasheva et al. (2023), who found an influence of tourist expenditure on increasing carbon emissions. Previously, a study was conducted by Kayani et al. (2023) with relatively the same results. This is very rational because increasing tourist expenditure will affect the increase in the supply of goods needed by tourists, so more energy is needed. Increasing energy use will affect carbon emissions. However, different results were found by Yıldırım et al. (2023); tourist expenditure did not affect the increase in carbon emissions. Furthermore, the study found increased carbon emissions if tourist expenditure was combined with several other variables. This happens because the interaction of several variables can give different results.

The impact of tourism on carbon emissions can also be through fuel expenditure. Increasing fuel consumption will undoubtedly increase carbon emissions. This is confirmed by research conducted by Raihan and Tuspekova (2022) and Raihan et al. (2023). Furthermore, tourism activities also cause an increase in waste in several tourist attractions, decreasing environmental quality (Bhuiyan et al., 2024). The decrease in environmental quality will affect the number of tourists who carry out tourism activities in the area. This is based on the results of research conducted by Jong et al. (2022). Research conducted by Wang and Xi (2023) proves that with the European Union's policy on oil prices, airline ticket prices have increased, and ultimately, there has been a decrease in the number of airline passengers. This means that the fuel price policy is one of the policies that can indirectly reduce carbon emissions. In addition, COVID-19 also caused a decrease in tourists, and the environmental quality increased (Osorio et al., 2023). Covid-19 can improve environmental quality.

This environmental quality will also affect tourist visits, or a decrease in environmental quality will affect the number of tourists. Jong et al. (2022) proved this by finding a causal relationship between tourism and environmental quality and environmental quality with tourists. In such a situation, there will be a challenging dilemma because increasing tourism will increase carbon emissions, causing environmental quality to decrease. A decrease in environmental quality will have a negative impact on tourist visits.

Although there is much empirical evidence that tourism affects increasing carbon emissions, there are also studies that find the opposite. For example, Tian et al. (2021) found different results because increasing tourism activities have an effect on reducing carbon emissions in the long term. This result is different from several other studies. Although only one result proves the negative effect of tourism on carbon emissions, it is enough to state that there needs to be a consensus on the results of the effect of tourism on carbon emissions.

Based on the various research results, it is essential to add references to support the findings that tourism positively affects carbon emissions or vice versa. These results will be one of the bases for policymakers in determining tourism sector development policies in Indonesia.

3. RESEARCH METHODS

3.1. Data Sources and Variables

This study analyzes the influence of tourism and several other variables on carbon emissions in Indonesia. The dependent variable is carbon emissions, while the independent variables are tourists, tourism, AVTUR, and expenditure. The data used ranges from 2010.1 to 2022.4, with 52 quarters. All data are transformed into natural logarithms except the contribution of the tourism sector to GDP. Explanations of the variables used in this study are shown in Table 1.

3.2. Econometric Approach

Many economic data are trending and have different stationarities, so the model must be adjusted to the conditions of the data used. Based on this fact, Pesaran et al. (2001) used the autoregressive distributed lag (ARDL) model approach, and the model was used in the study. This. The equation expresses the estimation model:

$$\Delta lnCO_{2t} = \beta_1 + \sum_{i=1}^{j2}\beta_2 lnCO_{2t-i} + \sum_{i=0}^{j3}\beta_3 ln\Delta lnEXP_{t-i} + \sum_{i=0}^{j4}\beta_4 \Delta lnTourist_{t-i} + \sum_{i=0}^{j5}\beta_5 \Delta TC_{t-i} + \sum_{i=0}^{j6}\beta_6 \Delta lnAVTUR_{t-i} + \theta_1 lnCO_{2t-1} + \theta_2 lnEXP_{t-1} + \theta_3 lnTourist_{t-1} + \theta_4 TC_{t-1} + \theta_5 lnAVTUR_{t-1} + \varepsilon_t \quad (1)$$

Table 1 explains the variables and their sources. Following the ARDL model, which can have various lag lengths, the short-term influence is cumulatively tested using Wald statistics. The formulation for testing the dynamic influence of each variable in the short term is stated in Table 2.

4. FINDINGS AND DISCUSSION

4.1. Estimation Procedures

The estimation process begins with a stationarity test on the variables used in this study using the Elliott-Rothenberg-Stock (ERS) approach because this approach is more efficient by including unknown mean and trend factors (Elliott et al., 1996) The results of the stationarity test are shown in Table 3.

Table 3 shows that the dependent variable is stationary after the first difference and equal to expenditure. Meanwhile, other variables are stationary at level, so the appropriate model used in this study is the Autoregressive Distributed Lag (ARDL) model. The short-term ARDL estimation results, based on the lag results, are in Table 4.

Table 1: Variables and their sources

No.	Variable	Description	Sources
1.	Carbon emissions (CO_2)	Yearly carbon emissions. The data are transformed into quarterly data (tons)	https://ourworldindata.org/co2-and-greenhouse-gas-emissions
2.	Tourists	Number of tourists that visited Indonesia	www.bps.go.id
3.	Tourism (TC)	The contribution of tourism sector to GDP (percent)	www.bps.go.id
4.	AVTUR	Jet fuel or aviation turbine fuel (kiloliters)	www.esdm.go.id
5.	Expenditure (EXP)	Average expenditure spent by tourists in Indonesia (USD)	www.bps.go.id

Table 2: Testing for dynamic short-run effect of the variables on the carbon emission

No.	Variable	Null hypothesis	Alternative hypothesis
1.	Expenditure (EXP)	$\sum_{i=0}^{j3}\beta_3 = 0$	$\sum_{i=0}^{j3}\beta_3 \neq 0$
2.	Tourists	$\sum_{i=0}^{j4}\beta_4 = 0$	$\sum_{i=0}^{j4}\beta_4 \neq 0$
3.	Tourism (TC)	$\sum_{i=0}^{j5}\beta_5 = 0$	$\sum_{i=0}^{j5}\beta_5 \neq 0$
4.	AVTUR	$\sum_{i=0}^{j6}\beta_6 = 0$	$\sum_{i=0}^{j6}\beta_6 \neq 0$

Source: Equation (1)

Table 3: Unit root test of the variables

Variable	Statistics		Critical value	Conclusion
	At level	First difference		
CO_2	3.5095	12.5377	5.7184	I (1)
Expenditure	0.1634	793.4196	5.7184	I (1)
Tourists	9.4712	-	5.7184	I (0)
TC	16,635	-	5.7184	I (0)
AVTUR	13.0318	-	5.7184	I (0)

Source: Estimated results, 2024

The short-term estimation results show that almost all variables are statistically significant. The expenditure variable in the early stage has a positive and significant effect on the first to third lags. Meanwhile, the tourist variable hurts in the early stage, but in the next stage, it has a positive and significant effect in the next period. The tourism sector variable provides negative, positive, and negative coefficients again, which are statistically significant. The last variable is AVTUR, which has a positive effect on two lags but is not significant on the other two lags.

Next, the long-term estimation results are provided in Table 5. All variables are highly significant with negative signs except AVTUR, which is positive. Long-term analysis will be provided in the next section.

Model stability testing from short-term to long-term using F-bound testing, as shown in Table 6. Table 6 shows that the F-statistic is greater than the critical value at all levels. This result confirms that the model has a short-term equilibrium to long-term equilibrium.

Model stability testing was carried out using Cusum and Cusum Squares, as in Figure 1. Figure 1 shows that both Cusum and Cusum Squares meet the requirements, so the model used in this study is stable and can be used as an analysis model.

5. DISCUSSION

The first analysis was conducted on all variables' short-term influence on Indonesia's carbon emissions. The expenditure variable has one negative and insignificant coefficient and three positive and significant coefficients, so this variable is stated to have a positive and significant influence on carbon emissions. Furthermore, the tourist variable has one negative and significant coefficient and two positive significant coefficients, so the accumulation of this variable's coefficient is significantly positive. The coefficient of the tourism variable is one positive but insignificant and two negative and significant coefficients, so the accumulation of this coefficient is significantly harmful. There are two significant AVTUR coefficients, and they are positive, so the accumulation of these two coefficients is positive.

The explanation of the accumulative effect shows that the short-term expenditure coefficient has a positive and significant effect on carbon emissions, and the results in Table 7 confirm this. Thus, the expenditure variable positively and significantly affects carbon emissions in the short term. The increase in tourists' spending will increase production capacity, so more energy is needed to produce the additional demand for carbon emissions to increase. This study's results align with the research conducted by Kayani et al. (2023) and Yıldırım et al. (2023). These results are very rational because the more significant the expenditure of tourists, the greater the production capacity, ultimately increasing carbon emissions.

The short-term effect of the tourist variable is also positive and significant, and this result is based on the short-term dynamic test in Table 7. This is rational because increasing the number of tourists will increase carbon emissions. This result is in line with several previous studies, including Koçak et al. (2020), Handoyo et al. (2022), Sun et al. (2022), and Arslan et al. (2023). However, the results of this study differ from the results of the study conducted by Tian et al. (2021).

Specifically, the AVTUR variable has a positive and significant effect in the short term, confirmed by its dynamic influence in the short term. This result is very appropriate because the increased number of passengers will increase the amount of carbon emissions. This result aligns with research conducted by Raihan and Tuspekova (2022) and Raihan et al. (2023).

Figure 1: Cusum and Cusum squares of model stability testing

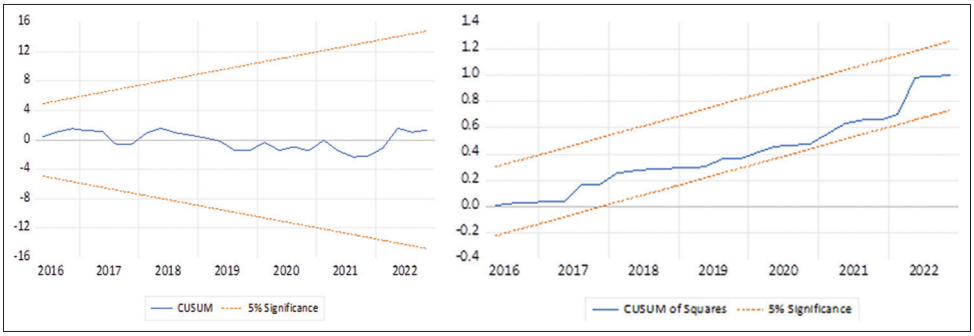

Table 4: Shot-run estimated results

Variable	Coefficient	Standard error	t-Statistic	Probability
D (LCO2[−1])	0.5098	0.1074	4.7457	0.0001
D (LEXP)	−0.0034	0.0095	−0.3588	0.7225
D (LEXP[−1])	0.0982	0.0238	4.1306	0.0003
D (LEXP[−2])	0.0759	0.0190	3.9901	0.0005
D (LEXP[−3])	0.0768	0.0157	4.8839	0.0000
D (LTOURIST)	−0.0207	0.0038	−5.4183	0.0000
D (LTOURIST[−1])	0.0272	0.0065	4.1571	0.0003
D (LTOURIST[−2])	0.0345	0.0064	5.3510	0.0000
D (TC)	−0.0904	0.0136	−6.6569	0.0000
D (TC[−1])	0.0122	0.0096	1.2788	0.2119
D (TC[−2])	−0.0525	0.0130	−4.0407	0.0004
D (LAVTUR)	0.0722	0.0308	2.3448	0.0266
D (LAVTUR [−1])	−0.0450	0.0342	−1.3154	0.1994
D (LAVTUR [−2])	0.0003	0.0347	0.0094	0.9925
D (LAVTUR [−3])	0.0794	0.0273	2.9031	0.0073
CointEq (−1)*	−0.1951	0.0262	−7.4559	0.0000

Source: Estimated results, 2024

Table 5: Long-run estimated results

Variable	Coefficient	Standard Error	t-Statistic	Probability
LCO2 (−1)*	−0.1951	0.0604	−3.2286	0.0033
LEXP (−1)	−0.1594	0.0299	−5.3302	0.0000
LTOURIST (−1)	−0.0683	0.0123	−5.5767	0.0000
TC (−1)	−0.0566	0.0327	−1.7286	0.0953
LAVTUR (−1)	0.2386	0.0828	2.8799	0.0077

Source: Estimated results, 2024

Table 6: F-bound test of finite sample

Test statistics	Value	Significant (%)	I (0)	I (1)
F-statistic	7.82	10	2.40	3.35
		5	2.85	3.91
		1	3.89	5.17

Table 7: Short-run dynamic effects of the variable

Variable	Statistics	P-value	Conclusion
Expenditure	9.6172	0.0000	Reject Ho
AVTUR	4.6816	0.0000	Reject Ho
Tourists	12.6349	0.0000	Reject Ho
Tourism	5.3459	0.0026	Reject Ho

Source: Estimated results, 2024

A long-term analysis is conducted based on Table 5, and some coefficients have anomalous effects in the long term because some coefficients have negative and significant signs. Previous carbon emissions have a negative and significant effect on carbon emissions in the current period. This condition indicates a contradiction because the increase in carbon emissions in the previous period should positively affect the next period.

The expenditure coefficient also negatively and significantly affects carbon emissions in the long term. This condition is inconsistent with previous studies' results because an increase in expenditure should affect increasing carbon emissions in the long term unless there is a state policy that seeks to produce more environmentally friendly goods so that increased production does not increase carbon emissions. Furthermore, tourists also have a negative and significant effect in the long term, so an increase in the number of visitors will decrease carbon emissions. This condition could occur if there is a restriction on the number of tourist visits with environmentally friendly conditions so that an increase in the number of tourists does not affect the increase in carbon emissions. The results of this study differ from the research of Koçak et al. (2020), Rehman et al. (2021), Raihan and Tuspekova (2022), and Raihan et al. (2023). The same result is also shown by the

tourism sector, which has a negative and significant influence on carbon emissions in the long term. This condition is in line with the tourist coefficient, which is negative and significant; increasing the contribution of the tourism sector will reduce emissions.

Only the AVTUR coefficient has a positive and significant coefficient, which is very much a reality because, with the increase in tourists, more AVTUR will be used. This condition will affect the increase in carbon emissions because AVTUR fuel is made of fossil fuel-based fuels. The results of this study confirm the research conducted by Wang and Xi (2023).

6. CONCLUSION

The results of this study present several conclusions. First, the short-term results show that expenditure, tourism, and AVTUR positively and significantly affect carbon emissions. Second, in the long term, only AVTUR has a positive and significant effect on carbon emissions, while other variables have a negative effect.

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