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"The Role of Research in Economics, Management, Accounting to Realizing Sustainable Development"

Study of Carbon Tax Policy Effectiveness and Public Socioeconomic Preferences in East Java

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ABSTRACT

As part of Indonesia's commitment to reduce carbon emissions and achieve the Net Zero Emission target, the implementation of carbon tax is one of the strategic steps that the government is beginning to pursue. However, the effectiveness of implementing a carbon tax is highly dependent on several factors, such as the tax rate level, policy design, public environmental awareness, and the level of public income. This study aims to analyze the effectiveness of carbon tax policies in East Java Province by examining the influence of these four variables through a public preference approach. Primary data will be collected by distributing questionnaires to respondents from various income levels and age groups in East Java. The data will be analyzed through regression modelling to identify which factors have the greatest impact on the effectiveness of the carbon tax. The results of this research are expected to produce a policy model that reflects public preferences and provide empirical insights for formulating a more effective and socially acceptable carbon tax scheme to support the Sustainable Development Goals.

Keywords: carbon tax, net zero emissions, sustainable development, effectiveness, public policy

INTRODUCTION

Climate change is currently becoming an increasingly urgent global challenge. The impacts of climate change can threaten the lives of all living beings through extreme temperature increases, food crises, increased frequency of natural disasters, rising sea levels, loss of biodiversity, and increased public health risks (IPCC, 2021). Climate change is triggered by the accumulation of greenhouse gas (GHG) emissions from human activities, including the burning of fossil fuels, deforestation, and industrial activities. GHGs consist of carbon dioxide (CO_2), methane (CH_4), water vapor, HFCs (Hydrofluorocarbons), PFCs (Perfluorocarbons), and SF_6 (Sulphur Hexafluoride), which play a role in trapping heat in the atmosphere.

The trend of global warming is becoming increasingly evident, including in Indonesia. According to the BMKG Climate and Air Quality Records (2024), 2024 is recorded as the hottest year since 1981, with an average temperature of 27.5°C, or an anomaly of +0.8°C compared to the normal period of 1991–2020. National air temperatures have consistently increased at a rate of 0.02°C per year, or the equivalent of +1°C in the last 44 years. In addition, sea levels in Indonesia have risen at a rate of 4.3 ± 0.4 mm per year between 1992 and 2024, indicating an increasing risk to coastal areas.

As a global response to climate change, many countries are beginning to implement carbon pricing instruments, such as carbon taxes, to internalize the negative externalities of emissions and encourage a transition to a low-carbon economy (OECD, 2021). Indonesia is one of the countries with a significant contribution to greenhouse gas emissions. According

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to Worldometer data, in 2022 Indonesia produced approximately 692 million tons of CO_2, contributing ±1.80% of total global emissions and ranking 6th in the world (Worldometer, 2022). Data from BPS show an increasing trend in total greenhouse gas emissions in Indonesia between 2019 and 2023, with total emissions reaching 1,053,476 $GgCO_2e$ in 2023 (BPS, 2025).

Indonesia's commitment to addressing climate change is demonstrated through the signing of the Paris Agreement in 2015 and the setting of a net-zero emissions target by 2050. The government is also integrating low-carbon development strategies through Presidential Regulation Number 18 of 2020 and implementing carbon tax as a Pigouvian tax to reduce the negative externalities of carbon emissions (Law on Harmonization of Tax Regulations No. 7 of 2021). Carbon taxes are levied on goods and activities that produce carbon emissions, with the aim of encouraging individuals and industrial sectors to transition to low-carbon economic practices.

Nevertheless, the effectiveness of carbon tax in Indonesia remains an important issue. Several studies indicate that effectiveness is influenced by the level of tax rates, policy design, public environmental awareness, and socio-economic conditions. Tjoanto & Tambunan (2022) highlight implementation barriers such as institutional readiness and industry resistance. Marisya, Ashfiya & Setyaningrum (2024) emphasize that public acceptance is a key factor in policy effectiveness, while Iqbal & Diana (2024) show that Indonesia's carbon tax rates are still much lower than in other countries, thus limiting its impact on emission reduction.

East Java province is a strategic area for assessing the effectiveness of carbon taxes because its economic structure is dominated by the manufacturing sector, which contributed 31.45% to the province's GRDP in 2023 and is a major contributor to carbon emissions (BPS East Java, 2024). The socio-economic diversity of society also influences the level of acceptance of carbon taxes, particularly regarding perceptions of benefits and cost burdens (Pamungkas & Haptari, 2022).

Therefore, a study on the effectiveness of carbon taxes in Indonesia, particularly considering the socio-economic preferences of the people in East Java, is crucial for generating more appropriate, effective, and equitable policy recommendations. This research will examine these factors to understand the extent to which carbon taxes can reduce emissions while also being accepted by the public.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Effectiveness of Carbon Tax

Carbon tax, also known as carbon emissions tax, is a tax levied on fuel consumption based on its carbon emission level (Saputra, 2021). Through this mechanism, every ton of emissions released into the atmosphere will be subject to an additional cost in the form of a tax. The aim is to encourage changes in economic behavior towards more efficient and environmentally friendly energy use (Baranzini & Weber, 2021). This tax not only serves as a source of state revenue but also as a tool for controlling negative externalities caused by carbon-based economic activities (Khasanova et al., 2022).

The conceptual basis for this policy stems from the theory of externalities proposed by Arthur C. Pigou (1920). According to Pigou, the market often fails to reflect the true social

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cost of an economic activity because some of its negative impacts are borne by parties other than the economic actors. This condition is called a negative externality. To correct these market failures, the government can implement a Pigovian tax, which imposes a financial cost on economic actors so that social costs can be internalized into the price of goods or services.

The effectiveness of a carbon tax depends on balancing environmental goals with social equity, ensuring the tax reduces emissions while minimizing the burden on vulnerable groups (Pranita & Sarjana, 2025). Effectiveness here refers to the success rate of carbon taxes in reducing carbon emissions through changes in energy consumption behavior and their acceptance by society as a fair and transparent policy. This public acceptance can be increased through transparency, reducing negative distributional effects, and investing revenue in environmental projects, in line with environmental goals (Haites et al., 2024).

Carbon Tax Rate

The carbon tax rate is the amount of tax levied on each unit of carbon dioxide (CO2) emissions generated by economic activities. This measure is generally expressed in dollars per ton of CO2 and is a key factor in determining the strength of economic incentives for individuals or industries to reduce emissions (OECD, 2023). The level of this tariff directly reflects the government's commitment to curbing carbon emissions, as the higher the tariff imposed, the greater the incentive for economic actors to innovate towards low-emission production activities.

In Indonesia, the government, through the Harmonization of Tax Regulations Law (UU HPP), sets carbon tax at Rp30 per kilogram of carbon dioxide equivalent (CO_2e), which is considered far below the global average (Kementrian Keuangan, 2021). Therefore, the effectiveness of this policy heavily relies on public perception of the fairness of the tariff. If society perceives that tax rates are not burdensome and are aligned with the environmental benefits obtained, then compliance with and support for the policy will increase (Sumner et al., 2011).

Carbon Tax Design

Carbon tax design includes implementation mechanisms, sector coverage, transparency in fund usage, and fairness and incentive systems within the policy framework. Good design will enhance the legitimacy and effectiveness of policies because it can address issues of fairness, clarity of purpose, and fiscal sustainability (Stiglitz, 2019). Additionally, a comprehensive policy design also ensures that the implementation of carbon taxes is not solely revenue-oriented, but truly becomes an instrument for transitioning towards a sustainable green economy.

In Indonesia, an effective carbon tax design needs to consider the differences in capacity between regions, including between industrial and non-industrial areas, such as in most of East Java. People tend to support policies with clear uses for their revenue, for example, when tax revenue received is allocated to local environmental management or the development of green energy. Thus, the design of carbon taxes can be measured based on public perception of policy fairness, public participation, and the transparency of how carbon tax revenue is used.

E-ISSN 3089-1566
Proceeding Accounting, Management, Economics Uniska Volume 2, 2025, pp 647-657
"The Role of Research in Economics, Management, Accounting to Realizing Sustainable Development"

Environmental Awareness

Environmental awareness describes the extent to which society understands and cares about the impact of human activities on their environment. In the context of carbon taxes, environmental awareness plays a crucial role because individuals with high levels of awareness are more likely to accept and support environmental policies, including carbon taxes (Harring et al., 2017). With the implementation of carbon taxes, it is hoped that it will be able to encourage a shift towards more environmentally friendly energy sources (Selvi et al., 2020).

Research conducted by Klenert et al. (2018) shows that support for carbon taxes increases significantly when the public is given clear information about the environmental benefits and transparent use of tax funds. This means that the government needs to provide clear understanding and information regarding the impact of human activities on the environment, environmental policies such as carbon taxes, and the transparency of carbon tax fund allocation.

Community Income

Community income is a crucial socioeconomic factor in evaluating tax policies, including carbon taxes. Theoretically, individuals with high incomes tend to be more capable of bearing the additional burden of carbon taxes, while low-income groups may perceive it as an economic burden that reduces their well-being (Bento et al., 2018). This aligns with research conducted by Douenne & Fabre (2020), which shows that support for carbon taxes increases with rising income and education levels in the community. This is because the group tends to have a better level of environmental literacy.

In the context of East Java, where income disparities still exist between regions, perceptions of carbon taxes may differ. Therefore, effective carbon policies must consider local economic conditions and the ability of communities to adapt to price changes resulting from taxes. Additionally, the successful implementation of carbon tax in East Java will also heavily depend on the proportionality of the tax applied to people's income and their willingness to pay the tax.

METHODS

This study employs a quantitative approach using multiple linear regression analysis to examine the influence of carbon tax rate, carbon tax design, environmental awareness, and income level on the effectiveness of the carbon tax policy in East Java Province. The quantitative approach was chosen because it allows for an objective, measurable, and generalizable understanding of the relationships among the variables studied.

The research was conducted in East Java Province, which was selected purposively due to its diverse socioeconomic characteristics, ranging from industrial to agricultural areas, as well as the variations in income levels among regions. These conditions enable the researcher to obtain a more representative public perception of the carbon tax policy. The study was carried out in 2025, coinciding with the ongoing phase of carbon tax implementation in Indonesia, which began in 2022.

The data used in this study are primary data, obtained directly from the distribution of questionnaires to residents of East Java. The use of primary data allows the researcher to capture the actual perceptions of the public regarding the effectiveness of the carbon tax

E-ISSN 3089-1566
Proceeding Accounting, Management, Economics Uniska Volume 2, 2025, pp 647-657
"The Role of Research in Economics, Management, Accounting to Realizing Sustainable Development"

policy. The respondents in this study consist of East Java residents who own motor vehicles or engage in activities that potentially produce carbon emissions, as these groups are directly affected by the carbon tax policy.

The sample size was determined using the formula proposed by Tabachnick and Fidell (2013):

$$N \geq 50 + 8m$$

where *N* represents the minimum sample size and *m* denotes the number of independent variables. With four independent variables, the calculation is as follows:

$$N \geq 50 + 8(5) = 50 + 40 = 90$$

Hence, the minimum number of respondents required for this study is 90 individuals. Data collection was conducted online using Google Forms, which were distributed through various social media platforms to reach respondents from different areas of East Java. After data collection, responses were filtered to ensure completeness and consistency before being processed using the SPSS statistical software.

The analytical procedure began with validity testing, which aims to determine whether the questionnaire items accurately measure the intended constructs. The validity test was conducted using the Pearson Product-Moment Correlation, and an item was deemed valid if the *r-count* value exceeded the *r-table* value (Sugiyono, 2019). Next, reliability testing was carried out to measure the internal consistency of the research instrument using the Cronbach's Alpha coefficient, with a variable considered reliable if its alpha value was ≥ 0.70 (Ghozali, 2021).

After the instrument was confirmed to be valid and reliable, multiple linear regression analysis was performed using the following model:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Note:
Y = the effectiveness of the carbon tax
X_1 = the carbon tax rate
X_2 = the carbon tax design
X_3 = environmental awareness
X_4 = community income
α = the constant
$\beta_1 - \beta_2$ = the regression coefficients of each independent variable
ε = the error term.

Prior to conducting regression analysis, classical assumption tests were performed to ensure that the model met the BLUE (Best Linear Unbiased Estimator) criteria. These tests included normality, multicollinearity, heteroscedasticity, and autocorrelation tests. Once the model satisfied these assumptions, hypothesis testing was conducted, consisting of the t-test (partial) to determine the effect of each independent variable on carbon tax effectiveness, the F-test (simultaneous) to examine the combined effect of the four variables, and the coefficient of determination (R^2) to assess the extent to which variations in carbon tax effectiveness are explained by the independent variables.

E-ISSN 3089-1566
Proceeding Accounting, Management, Economics Uniska Volume 2, 2025, pp 647-657
"The Role of Research in Economics, Management, Accounting to Realizing Sustainable Development"

RESULTS

Respondent Descriptive Statistics

The statistical calculations show that the majority of respondents were female 61 respondents (62.9%), and male 36 respondents (37.1%). Based on the respondents' ages, of the 97 respondents, the majority were between the ages of 20 and 26 (75.3%), 16 (16.5%) were between the ages of 13 and 19, 6 (6.1%) were between the ages of 27 and 33, and 2 (2.1%) were between the ages of 34 and 40. Based on their occupations, the majority of the 97 respondents were students 71 respondents (73.2%). 13 respondents (13.4%) worked as civil servants or private sector employees, 1 respondent (1%) was a lecturer, and 12 respondents (12.4%) chose other occupations. Based on income level, it can be seen that of the 97 respondents, most of the respondents have an income of <Rp 500,000, namely 31 (32%) people, 23 (23.7%) people have an income of Rp 500,000-Rp 1,500,000, 22 (22.7%) people have an income of >Rp 3,500,000, 13 (13.4%) people have an income of Rp 1,500,001-Rp 2,500,000, and 8 (8.2%) people have an income of Rp 2,500,001-Rp 3,500,000.

Validity And Reliability Test Results

Table 1. Validity Test Results

Variable/Indicator				
No	**Efektivitas Pajak Karbon**	**r-calculated**	**r table**	**description**
1	Y1	0,725	0,1996	Valid
2	Y2	0,750	0,1996	Valid
3	Y3	0,794	0,1996	Valid
4	Y4	0,814	0,1996	Valid
5	Y5	0,721	0,1996	Valid
	Tingkat Pajak Karbon			
1	X1.1	0,698	0,1996	Valid
2	X1.2	0,718	0,1996	Valid
3	X1.3	0,800	0,1996	Valid
4	X1.4	0,562	0,1996	Valid
5	X1.5	0,659	0,1996	Valid
	Desain Pajak Karbon			
1	X2.1	0,712	0,1996	Valid
2	X2.2	0,793	0,1996	Valid
3	X2.3	0,737	0,1996	Valid
4	X2.4	0,774	0,1996	Valid
5	X2.5	0,812	0,1996	Valid
	Kesadaran Lingkungan			
1	X3.1	0,648	0,1996	Valid
2	X3.2	0,690	0,1996	Valid
3	X3.3	0,675	0,1996	Valid
4	X3.4	0,713	0,1996	Valid
5	X3.5	0,746	0,1996	Valid
	Pendapatan Masyarakat			
1	X4.1	0,669	0,1996	Valid
2	X4.2	0,649	0,1996	Valid
3	X4.3	0,751	0,1996	Valid
4	X4.4	0,739	0,1996	Valid
5	X5.5	0,723	0,1996	Valid

Source: *Author's compilation*

E-ISSN 3089-1566
Proceeding Accounting, Management, Economics Uniska Volume 2, 2025, pp 647-657
"The Role of Research in Economics, Management, Accounting to Realizing Sustainable Development"

Table 1 shows that the correlation between each indicator and the total score of each variable shows valid results. This is because the r-calculated is greater than the table r. Therefore, it can be concluded that each statement item is valid.

Table 2. Reliability Test Result

No	Variable	Cronbach's Alpha	Standard alpha	Description
1	Efektivitas pajak karbon	0,815	0,600	Reliable
2	Tingkat pajak karbon	0,720	0,600	Reliable
3	Desain pajak karbon	0,823	0,600	Reliable
4	Kesadaran lingkungan	0,729	0,600	Reliable
5	Pendapatan masyarakat	0,750	0,600	Reliable

Source: *Author's compilation*

Table 2 shows that the results of the reliability test for all variables are declared reliable because all variables have a Cronbach's alpha value above.

Classical Assumption Test Results

Classical assumption tests were conducted to ensure that the regression model meets the necessary statistical requirements. These tests include normality, multicollinearity, heteroscedasticity, and autocorrelation. The Kolmogorov–Smirnov test for normality was performed on the residual values. The test results showed a significance value of 0.000, which is below the 0.05 level. Statistically, this indicates that the residuals are not normally distributed. However, in linear regression analyses with samples larger than 30, residual non-normality based on the K–S test is not a significant issue because the regression remains robust. Therefore, the model remains suitable for use. Multicollinearity testing showed that all independent variables had Tolerance values > 0.10 and VIF < 10, ranging from 0.364–0.413 for Tolerance and 2.424–2.748 for VIF, respectively. Based on these criteria, it can be concluded that the regression model does not exhibit multicollinearity, thus meeting these assumptions. Heteroscedasticity testing was performed using the Glejser Test. The results showed that the significance value of all independent variables was above 0.05 ($p > 0.05$). Thus, the model was declared free from heteroscedasticity and the residual variance could be considered homogeneous. The results of the autocorrelation test using Durbin–Watson produced a value of 1.980. This value is between the limits of dU (1.7560) and 4 – dU (2.2440), so it can be concluded that there is no autocorrelation in the regression model.

Multiple Linear Regression Analysis Results

Multiple linear regression analysis is used to test the effect of two or more independent variables on a dependent variable. The dependent variable in this study is "Carbon Tax Effectiveness," while the independent variables are "Carbon Tax Level," "Carbon Tax Design," "Environmental Awareness," and "Public Income." The equation used to test the overall hypothesis in this study is as follows:

E-ISSN 3089-1566
Proceeding Accounting, Management, Economics Uniska Volume 2, 2025, pp 647-657

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

E-ISSN 3089-1566
Proceeding Accounting, Management, Economics Uniska Volume 2, 2025, pp 647-657
"The Role of Research in Economics, Management, Accounting to Realizing Sustainable Development"

Table 3. Results of Multiple Linear Analysis

Coefficients			
Model	Unstandardized Coefficients		Standardized Coefficients
	B	Std. Error	Beta
(Constant)	0,202	1,505	
TOTAL_TPK	0,184	0,107	0,165
TOTAL_DPK	0,443	0,101	0,435
TOTAL_KL	0,287	0,111	0,252
TOTAL_PM	0,061	0,096	0,059

Source: *Author's compilation*

Based on table 3, the following equation is obtained:

$$Y = 0{,}202 + 0{,}184X_1 + 0{,}443X_2 + 0{,}287X_3 + 0{,}061X_4 + \varepsilon$$

The regression coefficient for the carbon tax rate variable (X_1) is positive at 0.184, indicating that an increase in the carbon tax rate tends to be followed by an increase in the effectiveness of the carbon tax, although the effect is not significant. The carbon tax design variable (X_2) has a coefficient of 0.443, indicating that the better the carbon tax policy design, the higher the effectiveness of its implementation. The environmental awareness variable (X_3) also shows a positive effect with a coefficient of 0.287, indicating that increased public awareness of environmental issues contributes to the increased effectiveness of the carbon tax. Meanwhile, public income (X_4) has a regression coefficient of 0.061, indicating a positive relationship but with a very small contribution to the effectiveness of the carbon tax. In general, this regression model illustrates that carbon tax design and environmental awareness are the variables that have the strongest influence in driving the effectiveness of the carbon tax.

Hypothesis Test Results

The results of the partial t-test hypothesis test indicate that each independent variable has a varying degree of influence on the effectiveness of the carbon tax. The carbon tax rate variable has a significance value of 0.088, indicating no effect on the effectiveness of the carbon tax, as this value is greater than 0.05. Conversely, the carbon tax design variable shows a significance value of 0.000, indicating a significant effect on the effectiveness of the carbon tax and is the most important factor in the model. The environmental awareness variable also has a significant effect, with a significance value of 0.011, indicating that increased public awareness of environmental issues contributes to the increased effectiveness of the carbon tax. Meanwhile, the public income variable has a significance value of 0.529, indicating no effect on the effectiveness of the carbon tax. Simultaneously, the F-test results show a significance value of 0.000, indicating that all independent variables together have a significant effect on the effectiveness of the carbon tax. In addition, the Adjusted R Square value of 0.656 explains that 65.6% of the variation in the effectiveness of carbon taxes can be explained by the variables of carbon tax levels, carbon tax design, environmental awareness, and community income, while the remaining 34.4% is influenced by other factors outside this research model.

E-ISSN 3089-1566
Proceeding Accounting, Management, Economics Uniska Volume 2, 2025, pp 647-657
"The Role of Research in Economics, Management, Accounting to Realizing Sustainable Development"

DISCUSSION

Based on the research that has been conducted and involved 97 respondents in the East Java Province community with a research instrument to measure the variables of carbon tax levels, carbon tax design, environmental awareness, and community income on the effectiveness of carbon taxes, from the validity and reliability tests it is known that all items from each are valid and reliable because the r-calculated of each of all variables is greater than the table r (r-calculated > table r).

The Effect of Carbon Tax Rates on Carbon Tax Effectiveness

The carbon tax rate variable has a significance value of 0.088 (>0.05), thus concluding that the carbon tax rate variable has no effect on the effectiveness of the carbon tax. Theoretically, carbon tax rates are designed to provide financial incentives for economic actors to reduce carbon emissions. However, the effectiveness of a tax policy is determined not only by the rate size but also by social acceptance, regulatory readiness, and implementation mechanisms. Various studies also indicate that tax rates that are too low do not encourage behavioral change, and even high rates are ineffective without strong institutional support. Thus, this finding aligns with the literature stating that tax rates, in the early stages of implementation, are not yet a key factor in increasing the effectiveness of carbon tax policies**.**

The Influence of Carbon Tax Design on Carbon Tax Effectiveness

The carbon tax design variable has a significance value of 0.000 (<0.05), thus concluding that the carbon tax design variable has a significant effect on the carbon tax effectiveness variable. Conceptually, the quality of policy design is a key element in the success of environmental fiscal instruments. The global literature on carbon pricing confirms that well-designed policies are more easily accepted by the public and more effective in changing emission behavior. Therefore, this finding is consistent with the theory that carbon tax effectiveness is strongly influenced by comprehensive policy design that is responsive to the social and economic context.

The Influence of Environmental Awareness on Carbon Tax Effectiveness

The environmental awareness variable has a significance value of 0.011 (<0.05), thus concluding that environmental awareness significantly influences carbon tax effectiveness. Environmental behavior theory suggests that public concern, risk perception, and understanding of ecological issues influence acceptance of climate mitigation policies. Communities with higher levels of environmental awareness tend to support carbon tax policies because they understand the urgency of reducing emissions. This finding aligns with previous research showing that climate education and literacy play a significant role in increasing the effectiveness of environmental fiscal policies.

The Influence of Community Income on Carbon Tax Effectiveness

The community income variable has a significance value of 0.529 (>0.05), thus concluding that the community income variable has no effect on the effectiveness of the carbon tax. Theoretically, income can influence an individual's ability to respond to fiscal

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"The Role of Research in Economics, Management, Accounting to Realizing Sustainable Development"

policy. However, with carbon tax instruments, the financial impact on the community is often indirect, especially in the early stages of implementation when tariffs are still low and sector coverage is limited. The climate policy literature also confirms that household economic factors are not the primary determinant of carbon policy effectiveness, particularly in developing countries still in the policy transition phase. Thus, income is not yet a key variable in determining how effectively a carbon tax policy is implemented on the community.

CONCLUSION

Research findings indicate that the effectiveness of a carbon tax is primarily determined by the quality of the policy design and the level of public environmental awareness. A clear, structured, and transparent carbon tax design is the most significant factor in driving the successful implementation of this policy. Furthermore, higher environmental awareness has been shown to strengthen public support and acceptance of climate mitigation policies. Conversely, the carbon tax rate and public income have no significant impact, indicating that the effectiveness of a carbon tax depends not only on the tariff or individual economic capacity, but more on the clarity of the instrument and public understanding of the urgency of emission reduction.

Based on these findings, this study offers several policy implications. The government needs to prioritize strengthening the design of carbon tax policies, including clarity on the tariff-setting mechanism, the scope of taxable sectors, and transparency regarding the use of tax revenue for climate mitigation programs. Furthermore, increasing environmental awareness through public education, climate literacy campaigns, and integrating climate change issues into the education curriculum are strategic steps to increase policy effectiveness. A policy approach that combines strong regulatory design and strengthening public understanding is believed to be able to strengthen public acceptance and ensure the long-term effectiveness of the carbon tax.

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