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Improving Social Acceptance for Carbon Taxation in South Korea†

By YEOCHANG YOON*

Carbon pricing is in the spotlight as an economically efficient policy to limit global warming and reduce greenhouse gas emissions. We examine how policymakers can improve social acceptance of a carbon tax, which is the main obstacle in implementing the policy. We conduct a survey experiment to analyze this topic and adopt two different interventions focusing on the use of revenue from a carbon tax and types of information to be provided. Regarding revenue use, we consider 1) tax reductions, 2) lump-sum transfers, and 3) green project investments. For information types, we focus on 1) the economic value of a carbon tax, and 2) the environmental value of a carbon tax. We find that lump-sum transfers have negative impacts on social acceptance of a carbon tax. For those who perceive climate change as a serious issue, moreover, both lump-sum transfers and tax reductions have negative impacts on acceptability. Regardless of the type of information provided, on the other hand, the social acceptance of a carbon tax is increased after the provision of information. Furthermore, the impact of information provision on the social acceptance interacts with the revenue use impacts. When the revenue use and the type of information are consistent with the aim of the policy, the effects of these strategies can be amplified.

Key Word: Carbon Tax, Carbon Pricing Mechanism, Climate Change, Policy Design
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I. Introduction

Increasing concern surrounding climate change has led to a global effort to reduce greenhouse gas (GHG) emissions. The EU, the United States, and many other countries have declared carbon neutrality goals to reach by 2050 and submitted the

* Associate Fellow, Korea Development Institute (E-mail: yoonyeochang@kdi.re.kr)
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updated their 2030 nationally determined contributions (NDCs). South Korea has also declared a goal of achieving net zero emissions by 2050 and raised their emissions reduction goal from 26.3% to 40% by 2030, compared to 2018 levels. Several different policies have been considered to achieve these ambitious targets. Carbon pricing is one of the most important instruments to help emitters reduce their emissions by internalizing the external costs of GHG emissions (Stiglitz, 2019). In relation to this, discussions of the Carbon Border Adjustment Mechanism have arisen and are applying pressure to adjust and improve the current carbon pricing mechanism. As a result, the importance of improving domestic carbon pricing mechanisms is an important topic in Korea.

Korea has an explicit carbon pricing mechanism, emissions trading system (ETS) as well as implicit carbon pricing through energy taxes. The Korean ETS was launched in 2015, covering a relatively wide range of sectors.[1] Although the ETS price is expected to surge to achieve the updated NDC targets and net zero emissions,[2] the imbalanced cost burden will become more serious between ETS and non-ETS sectors. On the other hand, Korea's current energy tax system has been criticized for being unbalanced across different industrial sectors and fuel types and for failing to reflect external costs sufficiently. The sustainability of the current energy tax system is also a subject of debate as the number of green cars increases. Hence, reforming the current energy tax system with the implementation of a carbon tax in non-ETS sectors is considered to be an effective and simple means of applying external costs to the tax rate while allowing the flexible use of tax revenue to fund various policies (Goulder and Parry, 2008).

This paper examines ways to address the crucial issue of public support for a carbon tax when implemented in Korea. Public opposition is the largest obstacle when implementing a carbon tax (Carattini *et al*., 2018). Despite the fact that a carbon tax is considered to be the most economically efficient policy to reduce emissions, public opposition has made many countries reluctant to implement such a policy. Australia abolished a carbon tax in 2014, and the state of Washington failed to pass related bills in 2016 and 2018. In Korea, the main target would be the non-ETS sector, i.e., small- and medium-sized firms as well as transport and buildings (Yoon, 2021).

This paper studies a survey experiment conducted to analyze how to improve the social acceptance of a carbon tax using different ways to apply carbon tax revenues and different types of information.[3] Several tax revenue uses are considered, such as reductions of existing taxes, lump-sum transfers to households, and investments in green projects. The information provided includes details of a carbon tax with emphasis on either its economic value or its environmental value. To the best of the authors' knowledge, this paper is the first attempt to investigate how carbon taxation acceptability in Korea is contingent upon the utilization of the tax revenues. In addition to prior research, this study analyzes the impact of the interaction between

[1]The Korean ETS covers about 73.5% of national GHG emissions, while the EU ETS covers about 39% of the EU's total GHS emissions.

[2]The IMF expects the global carbon price to rise to $75 per ton of CO_2 by 2030, while the average price of the Korean ETS in 2021 was around $20.

[3]Anderson *et al.* (2019) and Douenne and Fabre (2020) point out that the main reasons for the opposition not only include the carbon tax itself but also the policy design and information provided.

the use of tax revenues and types of information provided on the social acceptability of carbon taxation.

The analysis of tax revenue uses shows that lump-sum transfers reduce support in general. Categorizing individuals based on concern over climate change specifically shows that reductions of existing taxes may have positive effects on support for a carbon tax when an individual does not consider climate change to be a serious issue. On the other hand, when an individual considers climate change to be serious, tax revenue uses beyond investments in green projects show negative effects. Thus, green project investment is a revenue application that does not show negative impacts on support in general and at different levels of climate concern as well.

Dolsak *et al*. (2020), who employed a methodology similar to ours to study this issue in the United States, also found a similar order of effects on acceptability across various revenue uses. They found that using the revenue from carbon taxation for mitigation efforts increased overall acceptability, while lump-sum transfers or tax reductions did not improve acceptability. Our study similarly demonstrates that investments in green projects are more acceptable than lump-sum transfers.[4] Moreover, our study shows that investments in green projects are more favorable for acceptability than both lump-sum transfers and tax reductions, particularly among individuals with a greater awareness of climate change.

Providing information improves subjects' acceptance of a carbon tax in the short run, regardless of the type of information. In addition, differences in the acceptance change according to how the tax revenue is used remain constant even after efforts to improve acceptance via information provision. This implies that when designing and implementing a carbon tax, differences in acceptance according to the policy design should be considered. Furthermore, tax revenue uses and the provision of information enhance the acceptance of a carbon tax when their implications are consistent with each other. Therefore, the aim of the policy, the design of the policy, and the information provided should be consistent overall to improve the social acceptance of such a policy.

The remainder of the paper is structured as follows. Section II reviews the literature on the acceptability of a carbon tax. Section III explains how the survey experiment is designed to investigate the impacts of the different revenue uses and information types on social acceptance, and Section IV analyses the results. Section V provides the conclusion and policy implications.

II. Literature Review

A. *Different Revenue Uses from a Carbon Tax*

Concerns surrounding a carbon tax arise due to the negative effects on the economy, the possibility of aggravating income distribution, or the questionable impact on reducing greenhouse gas emissions. These concerns are strongly related

[4]Mildenberger *et al.* (2022), who studied certain Canadian provinces and Switzerland as they implemented lump-sum transfers as a use of tax revenues from a carbon tax, also demonstrated that the impact of utilizing tax revenues through lump-sum transfers on acceptability is limited.

to how the revenue from a carbon tax will be used.

First, carbon tax revenue can be used to reduce existing taxes, including income taxes, consumption taxes, and corporate taxes, which is an approach closely related to the double-dividend hypothesis. Pearce (1991) was the first to propose the double-dividend hypothesis, which states that the implementation of a carbon tax can achieve both economic and environmental benefits while holding government revenue constant. This arises because a carbon tax will not only improve the environment by providing incentives to reduce GHG emissions but will also improve the effectiveness of the entire tax system by reducing reliance on highly distortionary taxes.

To alleviate the negative impact on income distribution, revenue can be used to support low-income households or provide lump-sum transfers to all households. It is possible that a carbon tax will be regressive, increasing the burden of energy costs relative to income. Lump-sum transfers can benefit low-income households who receive higher proportions relative to income, meaning that a carbon tax could be progressive (Metcalf, 2009; Goulder *et al*., 2019; Fremstad and Paul, 2019).

Investing the carbon tax revenue into green infrastructure and R&D is another way to use the revenue. This approach not only induces efforts in the short run but also promotes GHG emissions reductions in the long run by establishing the infrastructure for energy and industrial transformation. Furthermore, this strategy promotes technological breakthroughs through investments in R&D, thereby maximizing the effects of efforts to reduce emissions (Jaffe *et al*., 2005; Kim *et al*., 2015; Lilliestam *et al*., 2020).

B. *Change in Acceptance by Revenue Use*

Using carbon tax revenues in different ways can affect public support for a carbon tax (Saelen and Kallbekken, 2011; Jagers and Hammar, 2009; Baranzini and Carattini, 2017). Maestre-Andres *et al.* (2019) reviewed various studies of the effect of revenue use on public support. They found that most studies reported that using the revenue for environmental projects is the most preferred, while people have concerns about distributional effects. Many people are skeptical whether a carbon tax will effectively reduce GHG emissions and whether the revenue should be used to reinforce emissions reduction efforts. Using the revenue for lump-sum transfers, on the other hand, showed contradictory results. Kaplowitz and McCright (2015) found that policy acceptability increased via a tax rebate in the U.S., while Jagers *et al.* (2019) showed that it decreased public support in the Swedish case. Beuermann and Santarius (2006) and Dresner *et al.* (2006) noted that the use of revenue as tax reduction is the preferred measure among economists but is at the same time the most unpopular way of using revenue among the public.

Dolsak *et al.* (2020) conducted a survey similar to that here to assess changes in acceptance for different method of revenue use, in their case tax reduction, compensation to the low-income households, mitigation, and adaptation. Support was found to vary among groups depending on how the revenue is to be used, ranging from 47.4% to 61.4%. In particular, using the revenue for mitigation generates 6.3% higher support relative to the control group for which no particular revenue use is proposed. The rate is consistently high regardless of political inclination or income level. For other revenue uses, the rate of support varies depending on political

inclination and income level.

C. *Changes in Acceptance by Information Provision*

Information provision has been discussed as another way to improve the acceptance of a carbon tax. Carattini *et al.* (2018), Hammar and Jagers (2006), and Jagers and Hammar (2009) showed that providing information regarding the mitigating effects of a carbon tax on GHG emissions reduction could help to address concerns surrounding the effectiveness of a carbon tax and thereby could increase acceptance. Douenne and Fabre (2020) showed that concern over climate change is the crucial factor behind the acceptance of a carbon tax and proposed an information campaign regarding climate change in order to increase acceptance.

Concerns over climate change have also led to discussions regarding the effectiveness of information provision. In relation to this, van der Linden *et al.* (2015) revealed that scientific consensus information has a positive impact on climate change concerns. On the other hand, Cook and Lewandowsky (2016) showed that such information may have different effects across countries. The information improved overall awareness in Australia but led to potentially negative effects in the U.S. depending on the individuals' political inclinations.

III. Design of the Survey Experiment

This research investigates the impacts of different revenue uses and information provision on acceptance for a carbon tax. To analyze these effects, a combination of a between-subject design and a within-subject design is considered. Both of these designs are adopted to assess not only each effect, but also their interactions.

The between-subject design is used to analyze the impact of different revenue uses on acceptance. Subjects are divided into four groups, with each group receiving a different revenue use proposal. These are denoted as the control group, tax reduction group, lump-sum transfers group, and green projects investment group. P_0 is the control group, for which the revenue use is not specified. For P_1 tax reduction, for P_2 lump-sum transfers, and for P_3 green project investments are suggested as the revenue use method, respectively.

TABLE 1—POLICY INTERVENTIONS[5]

Revenue Use	Frame	Message
P_0	Control Group	-
P_1	Tax Reduction	Reduction in income tax and consumption tax → Environmental achievement + economic achievement
P_2	Lump-sum Transfers	Lump-sum transfers to all citizens → Reduced burden on low-income households
P_3	Green Projects	Technological innovation + investment into infrastructure → GHG emission reduction in long-run

[5]The full messages are provided in the appendix.

TABLE 2—INFORMATION INTERVENTIONS

Information Type	Frame	Message
I_1	Economic Value	Economic damage following climate change + Positive effect of a carbon tax on the economy
I_2	Environmental Value	Environmental damage following climate change + Positive effect of a carbon tax on the environment

To compare the types of information, the groups were divided based on whether they receive information about the economic value of a carbon tax or the environmental value of a carbon tax.[6] I_1 receives information on the economic value of a carbon tax, including information such as the environmental damage from climate change and the economic contribution of a carbon tax. In addition, the information includes the message that a carbon tax is believed to be the most efficient way to reduce GHG emissions by most economists. I_2 receives information on the environmental value of a carbon tax, including the environmental damage following climate change and the environmental contribution of a carbon tax. This group also receives the consensus message that most climate scientists agree that climate change is caused by human behavior, as used in van der Linden *et al.* (2015).

A within-subject design separates the revenue use groups into two groups and provides different information in order to analyze changes in acceptance following the provision of information. As presented in Table 3, subjects were categorized here into eight groups. Below, Group 3 receives a lump-sum transfer as a means to use the revenue and information about the economic value.

The procedure of the survey experiment is shown in Figure 1. Prior to surveying acceptance, truncated information regarding a carbon tax was provided, after which a quiz was given to assess the subjects' basic understanding of a carbon tax. An additional survey was only conducted with subjects who answered the quiz properly.[7] The proposed carbon tax rate was a rate of ₩30,000/tCO_2e, similar to the average price of the ETS allowance in 2020. Then, with the different revenue uses proposed for the different treatment groups, carbon tax acceptance was surveyed on a scale of 21 encompassing integers between –10 and 10. Given the question 'Do you support the implementation of a carbon tax?', -10 indicates "Strongly Disagree," while 10 indicates "Strongly Agree." In addition, a different type of information was provided to each group, acceptance of a carbon tax was resurveyed, and sociodemographic factors including the level of climate change concern were surveyed during the post-survey step.

TABLE 3—GROUP DESIGN

	P_0	P_1	P_2	P_3
I_1	Group 1	Group 2	Group 3	Group 4
I_2	Group 5	Group 6	Group 7	Group 8

[6]This study categorizes information into two types in order to distinguish the separate effects of different types of information and to analyze their interaction with the use of tax revenue.

[7]Overall, 74.99% of the subjects passed the quiz.

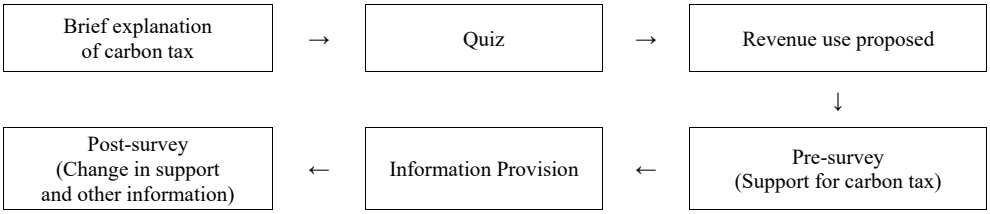

FIGURE 1. SURVEY EXPERIMENT PROCEDURE

TABLE 4—SURVEY EXPERIMENT DESIGN

	First Round	Second Round	
	Main Survey	*Resurvey*	*New Survey*
Number of Subjects	3,200 Subjects (8 Groups x 400 Subjects)	400 Subjects (8 Groups x 50 Subjects)	1000 Subjects (10 Groups x 100 Subjects)
Survey Period	2021. 6. 28. ~ 2021. 7. 6.	2021. 9. 23. ~ 2021. 10. 6.	

The important parts of the message in each step were highlighted in bold, such that only reading the highlighted part would be enough to understand the message. To ensure sufficient reading of each message, the "Next" button was deactivated for a certain time so that subjects could not immediately move on to the next message without reading the message. Furthermore, subjects could not access previous questions.

The survey was divided into two rounds and both were conducted online. In the first round, the *Main Survey* was presented to eight groups following the above procedure. Each group included 400 subjects; hence, 3,200 subjects in total were surveyed. Subjects were initially stratified based on gender and age and were then randomly assigned to either the control group or to one of the treatment groups. The second round was conducted three months after the first round, with 50 subjects from each group of the first round being selected randomly for the *Resurvey* to assess the long-term effects and external validity of the experiment.[8] The *New Survey* in the second round included new subjects not from the first round to avoid any confounding effects caused by the time point of the survey experiment.[9] In the *New Survey*, there were two tax reduction groups – the income tax reduction group and the consumption tax reduction group – because their impacts on income distribution may be different. Hence, we used ten groups. However, the two groups were later merged because no significant changes were found between them.

IV. Analysis

A. *Summary Statistics and Basic Data Analysis*

Prior to analyzing the results of the survey experiment, Table 5 presents the summary statistics of the survey data. The *Main Survey* includes 3,200 subjects, and

[8]The *Resurvey* excluded the quiz from the first round and followed the same procedure used in the pilot survey of the *Main Survey*.

[9]The new subjects were asked the same questions that were asked in the first round.

TABLE 5—SUMMARY STATISTICS OF THE MAIN VARIABLES

	Main Survey (First-Round)	*New Survey* (Second-Round)
Gender (Female=1)	0.5 (0.5)	0.5 (0.5)
Education (Undergraduate or higher=1)	0.84 (0.37)	0.87 (0.34)
Age	39.97 (11.75)	39.32 (10.87)
Household Income (₩4 million/month or higher=1)	0.61 (0.49)	0.64 (0.48)
Married	0.56 (0.50)	0.57 (0.49)
Child	0.30 (0.46)	0.34 (0.47)
Location (Capital Area=1)	0.56 (0.50)	0.56 (0.50)
Religion	0.41 (0.49)	0.38 (0.49)
Politics†	-0.54(3.67)	-0.68(3.47)
Climate Concern	6.05 (3.69)	4.91 (3.59)
Sample size	3,200	1,000

Note: 1) † The variable politics is investigated on a scale ranging from -10 to +10, where a higher value indicates a conservative position and a lower value indicates a progressive position; 2) Figures in the table represent the average value, and ( ) represents the standard deviation.

TABLE 6—AVERAGE ACCEPTANCE RATE FOR EACH GROUP

	Pre-Survey	Post-Survey	
Full Sample	1.36 (4.88)	2.07 (4.88)	
Control Group (P_0)	1.74 (4.90)	Group 1 (I_1)	2.27 (4.80)
		Group 5 (I_2)	2.57 (4.75)
Tax Reduction (P_1)	1.39 (4.82)	Group 2 (I_1)	2.35 (4.67)
		Group 6 (I_2)	2.05 (5.14)
Lump-sum Transfers (P_2)	0.65 (4.92)	Group 3 (I_1)	1.51 (4.80)
		Group 7 (I_2)	1.28 (5.04)
Green Projects (P_3)	1.69 (4.81)	Group 4 (I_1)	2.08 (4.98)
		Group 8 (I_2)	2.41 (4.73)

Note: Figures in the table represent the average value of acceptance, and ( ) represents the standard deviation.

the *New Survey* includes 1,000 subjects, meaning that a total of 4,200 subjects were surveyed in this part of the experiment. In each survey, subjects are equally distributed into each group based on gender and age.[10]

The average value of acceptance for a carbon tax, as shown in Table 6, is 1.36 for the full sample based on the pre-survey. If a value of acceptance above 0 is categorized as indicating support a carbon tax, the rate of support is 48.9% in the full sample. In the post-survey conducted after the information was provided, the average value of acceptance is 2.07 and the rate of support is 61.2% in the full sample.

B. *Policy Effect*

An ordered probit model is employed to analyze changes in the acceptance of a

[10]It should be noted that climate change concern was reduced in the second round relative to that in the first round. This issue will be addressed further in the analysis part concerning policy effects.

carbon tax for each type of revenue use. The dependent variable is the acceptance of a carbon tax, surveyed at a scale of 21 with a range from -10 to +10.[11] An explanatory variable is a dummy variable for policy intervention, P_j, which represents the type of the revenue use, with $j = 0, 1, 2, 3$. P_0 equals 1 for groups 1 and 5 and equals 0 otherwise. Similarly, P_1 equals 1 for groups 2 and 6, P_2 equals 1 for groups 3 and 7, and P_3 equals 1 for groups 4 and 8. Other independent variables that have an effect on the acceptance of a carbon tax are also chosen, in this case gender, education, age, household income, marriage status, having a child, residential location, and religion.

We begin by assessing differences in the effects across revenue use by comparing the control group (P_0) with the treatment groups (P_1, P_2, P_3).[12] As shown in column (1) of Table 7, earmarking the revenue use lowers acceptance compared to this outcome in the control group. In other words, earmarking the revenue use has negative effects on the acceptance of a carbon tax. As shown in column (2) of Table 7, the negative impact of the earmarking of revenue use is due to lump-sum transfers. Specifically, for each revenue use, acceptance is significantly lower when lump-sum transfers are suggested, which results in a negative impact from earmarking. On the other hand, tax reductions and green project investments do not have significant effects on acceptance under the full sample.

Assessing the effects of the socio-demographic factors on acceptance shows that household income, education, and the level of climate concern have positive effects in general. These findings correspond to the analysis in Thalmann (2004) and Hsu *et al.* (2008), who found that education and income level have positive effects on the acceptance of a carbon tax, and Kotchen *et al.* (2017), who analyzed the effects of opinions about global warming on the acceptance of a carbon tax. Among the politically more conservative, acceptance is lower, which is consistent with Dolsak *et al.* (2020).

[11]In general, five-point or seven-point Likert scales are commonly used for measurements to avoid complexity (Cox, 1980; Weng, 2004; Hawthorne *et al*., 2006). However, in Fryer *et al*. (2019), a 17-point Likert scale was used to capture changes in subjects' beliefs about climate change after the provision of information. Our study employs greater granularity in the measurements to investigate the interaction between the use of carbon tax revenue and the types of information provided.

[12]Carattini *et al.* (2018) reviewed the literature on the relationship between the use of the revenue from a carbon tax and acceptance. They showed that the effect of earmarking the revenue from carbon taxation on acceptability depends on how the revenue is utilized, and even with the same revenue use, there can be differences between countries.

TABLE 7—ACCEPTANCE OF CARBON TAX WITH VARIOUS REVENUE USES

		(1) Earmarking Effect	(2) Policy Effect
Non-Control Groups ($P_j = 1,\ j = 1,2,3$)		-0.093** (0.037)	-
Policy Change	Tax Reduction ($P_1 = 1$)	-	-0.051 (0.044)
	Lump-sum Transfers ($P_2 = 1$)	-	-0.231*** (0.046)
	Green Projects ($P_3 = 1$)	-	-0.006 (0.046)
	Gender	0.002 (0.032)	0.003 (0.032)
	Education	0.143*** (0.045)	0.144*** (0.045)
	Age	0.001 (0.002)	0.001 (0.002)
	Household Income	0.060* (0.034)	0.067* (0.034)
	Married	-0.002 (0.053)	-0.012 (0.053)
	Child	0.036 (0.044)	0.037 (0.044)
	Location	0.044 (0.032)	0.037 (0.044)
	Religion	0.020 (0.032)	0.018 (0.033)
	Politics	-0.051*** (0.004)	-0.051*** (0.004)
	Climate Concern†	0.793*** (0.054)	0.795*** (0.054)
	Surveyed Date (*New Survey*=1)	-0.133*** (0.037)	-0.142*** (0.038)
	Cutoffs††	✓	✓
	Sample Size	4,200	4,200
	Pseudo R^2	0.0198	0.0210

Note: 1) † The climate change variable is used as a dummy variable to improve the accuracy of the empirical model analysis. It is set to 1 if the response variable is positive and 0 otherwise; 2) †† Because this study uses a 21-point Likert scale, there are 20 cutoffs in the ordered probit model. Given these numerous cutoffs, we omitted them from the table; 3) *, **, and *** correspondingly represent significance at the 10%, 5%, and 1% levels, and ( ) is the standard error; 4) The analysis above includes the results of the pre-survey from the *Main Survey* and *New Survey*.

C. *Differences in Policy Effects According to the Level of Climate Concern*

For a deeper analysis of the differences in acceptance across revenue use types, the subjects are categorized based on their level of climate concern. On a scale from -10 to 10, they are classified as having low climate concern when the score is negative and high climate concern when the score is non-negative.

As shown in Table 8, the results when including and excluding the *New Survey*, respectively, show differences in acceptance across different categories of climate concern among the tax reduction group. Only looking at the *Main Survey* in columns (1) to (3) of Table 8 shows that when climate concern is low, the suggestion of a tax reduction increases acceptance. When climate concern is high, however, revenue

TABLE 8—ACCEPTANCE OF A CARBON TAX WITH VARIOUS TYPES OF REVENUE USE DEPENDING ON THE LEVEL OF CLIMATE CONCERN

		Main Survey and *New Survey*			
		(1) Low Climate Concern	(3) High Climate Concern	(4) Low Climate Concern	(6) High Climate Concern
Revenue Uses	Tax Reduction	0.304* (0.174)	-0.081 (0.054)	0.151 (0.149)	-0.062 (0.046)
	Lump-sum Transfers	0.253 (0.171)	-0.252*** (0.054)	0.170 (0.154)	-0.265*** (0.048)
	Green Projects	0.272 (0.172)	-0.013 (0.054)	0.155 (0.156)	-0.024 (0.048)
Gender		0.165 (0.135)	-0.007 (0.039)	0.250** (0.117)	-0.009 (0.034)
Education		0.310* (0.161)	0.108** (0.054)	0.229 (0.143)	0.136*** (0.048)
Age		-0.015** (0.007)	0.003 (0.002)	-0.014** (0.006)	0.003 (0.002)
Household Income		-0.162 (0.129)	0.132*** (0.041)	-0.210* (0.113)	0.089** (0.036)
Married		0.337 (0.211)	-0.009 (0.063)	0.245 (0.180)	-0.036 (0.055)
Child		-0.196 (0.180)	-0.001 (0.054)	-0.043 (0.153)	0.045 (0.046)
Location		0.051 (0.121)	0.024 (0.039)	0.018 (0.106)	0.045 (0.034)
Religion		-0.015 (0.130)	0.047 (0.040)	-0.041 (0.115)	0.024 (0.035)
Politics		-0.044** (0.018)	-0.052*** (0.005)	-0.042*** (0.0153)	-0.053*** (0.005)
Surveyed Date (*New Survey*=1)		-	-	-0.543*** (0.129)	-0.108*** (0.039)
Cutoffs		✓	✓	✓	✓
Sample Size		332	2,868	431	3,769
Pseudo R^2		0.0153	0.0100	0.0250	0.0101

Note: *, **, and *** correspondingly represent significance at the 10%, 5%, and 1% levels, and ( ) is the standard error.

uses other than green project investments lead to lower acceptance at a significant level.

On the other hand, the results that include the *New Survey* in columns (4)-(6) of Table 8 show that the effects of a tax reduction are not significant, although their signs remain the same with the cases of the *Main Survey* only. Another point is that when climate concern is low, the negative effect of the survey date in the *New Survey* is estimated to be quite significant. This is different from the results among subjects whose climate concern level is medium or high. Between the first round (late June of 2021 to early July of 2021) and the second round (late September of 2021 to early October of 2021), a draft of the Carbon Neutrality Roadmap was announced and the NDC target was discussed in Korea. Andersen *et al*. (2019) showed that once policies related to carbon neutrality come under official scrutiny, costs related to GHG reduction are realized and related negative information spreads through various media, likely leading to this difference in the results. In particular, this effect appears

more pronounced when climate concern is low.

D. *Change in Acceptance after Information Provision*

Thus far, we have focused on the pre-survey to analyze the changes in acceptance among each type of revenue use. Next, in order to analyze the improvement in acceptance following the provision of information, we investigate both pre-survey and post-survey outcomes. To analyze differences according to the type of information, we use an indicator variable, I_2. This variable equals 1 when the provided information focuses on the environmental value of a carbon tax and equals 0 otherwise.

The dependent variable in column (1) of Table 9 is the difference in acceptance before and after information provision. The constant term, estimated to be positive with statistical significance, implies that information provision has a positive effect

TABLE 9—CHANGE IN ACCEPTANCE AFTER INFORMATION PROVISION

		(1) Change in Acceptance by Information	(2) Post-Survey Acceptance
Revenue Use	Tax Reduction	0.077* (0.046)	-0.007 (0.044)
	Lump-sum Transfers	-0.002 (0.047)	-0.221*** (0.046)
	Green Projects	-0.057 (0.047)	-0.031 (0.046)
Information Type ($I_2 = 1$)		0.010 (0.033)	0.008 (0.031)
Gender		0.222*** (0.033)	0.076** (0.032)
Education		0.008 (0.047)	0.141*** (0.045)
Age		-0.001 (0.002)	0.000 (0.002)
Household Income		0.001 (0.035)	0.060* (0.034)
Married		0.061 (0.055)	0.023 (0.052)
Child		-0.085* (0.046)	0.015 (0.044)
Location		-0.045 (0.033)	0.009 (0.032)
Religion		-0.035 (0.034)	0.039 (0.033)
Politics		0.003 (0.005)	-0.497*** (0.004)
Climate Concern		0.298*** (0.056)	0.918*** (0.054)
Surveyed Date (*New Survey*=1)		-0.052 (0.039)	-0.187*** (0.037)
Cutoffs		✓	✓
Sample Size		4,200	4,200
Pseudo R^2		0.0071	0.0239

Note: *, **, and *** correspondingly represent significance at the 10%, 5%, and 1% levels, and ( ) is the standard error.

on acceptance, at least in the short run. On the other hand, the information type was not related to significant differences in acceptance, except in the case of tax reductions.

Column (2) in Table 9, which presents the analysis results for the post-survey acceptance of a carbon tax after information provision, shows that lump-sum transfers still have a negative effect on significance. The implication here is that despite having provided information to improve acceptance, the effect of revenue use on post-survey acceptance remains similar to the level of pre-survey acceptance.

E. *Interaction between the Policy Effect and Information Effect*

Additionally, we analyzed whether providing a different type of information with each revenue use would lead to heterogeneous effects. These results show an interaction effect between the uses of revenue and the types of information. Given a tax reduction as the type of revenue use, information pertaining to the economic values of a carbon tax has a positive effect on acceptance. For green project investments, on the other hand, information about the environmental value of a carbon tax has a positive effect on acceptance. In other words, when P_1 and I_1 are combined or when P_3 and I_2 are combined, the positive effect of information

TABLE 10—INFORMATION PROVISION EFFECT DEPENDING ON REVENUE USE AND INFORMATION TYPE

	(2) Control Group	(3) Tax Reduction	(4) Lump-sum Transfers	(5) Green Projects
Information Type ($I_2 = 1$)	0.050	-0.147**	-0.037	0.199***
	(0.068)	(0.061)	(0.067)	(0.068)
Gender	0.158**	0.236***	0.264***	0.257***
	(0.069)	(0.062)	(0.068)	(0.068)
Education	-0.083	-0.037	0.021	0.129
	(0.096)	(0.087)	(0.096)	(0.096)
Age	-0.010**	0.005	-0.004	0.001
	(0.004)	(0.004)	(0.004)	(0.004)
Household Income	-0.076	0.041	0.044	0.012
	(0.074)	(0.066)	(0.074)	(0.072)
Married	0.325***	-0.080	0.102	-0.033
	(0.112)	(0.101)	(0.116)	(0.112)
Child	-0.225**	-0.101	-0.099	0.082
	(0.095)	(0.084)	(0.096)	(0.093)
Location	0.058	-0.030	-0.072	-0.130*
	(0.069)	(0.062)	(0.068)	(0.069)
Religion	-0.023	-0.012	0.063	0.114
	(0.071)	(0.065)	(0.070)	(0.071)
Politics	0.012	0.006	-0.007	-0.001
	(0.010)	(0.008)	(0.010)	(0.009)
Climate Concern	0.166	0.448***	0.199*	0.341***
	(0.120)	(0.101)	(0.113)	(0.117)
New Survey	-0.092	-0.101	0.136	-0.109
	(0.085)	(0.065)	(0.083)	(0.084)
Cutoffs	✓	✓	✓	✓
Sample Size	1,000	1,200	1,000	1,000
Pseudo R^2	0.0076	0.0123	0.0081	0.0135

Note: *, **, and *** correspondingly represent significance at the 10%, 5%, and 1% levels, and ( ) is the standard error.

provision on acceptance is greater. However, such interaction effects are not observable in P_0 or P_2.

P_1 denotes a type of revenue use designed to achieve goals not only on the environmental frontier but also on economic frontiers, and I_1 emphasizes the economic value of a carbon tax. Similarly, P_3 is suggested to maximize emissions reduction while I_2 emphasizes the environmental value of a carbon tax. Hence, information provision interacts with revenue use in affecting acceptance levels and shows greater effects when the policy design and information provision match with regard to their goals.

F. *Long-run Effect*

The *Resurvey* in the second round was conducted on 50 individuals per group (for a total of 400 individuals) from the first round of surveys three months after the first round of the surveys. In the *New Survey* of the second round, new individuals were also surveyed simultaneously.

To analyze the long-run effect of the *Main Survey*, we analyze whether resurveyed individuals who were surveyed three months prior display greater acceptance relative to newly surveyed individuals.[13] Columns (1) and (2) in Table 11 show the analysis results regarding their acceptance levels. (1) does not include climate concern as an independent variable, while (2) includes this variable.

As shown in column (1) of Table 11, having participated in the first round of surveys has a positive effect on acceptance. In addition, the comparison of the results in (1) and (2) shows that *Resurvey* affects acceptance indirectly through climate concern. The results in (3) confirm a positive effect of *Resurvey* on climate concern. As explained previously, it is possible that some negative news was delivered between the first and the second round. However, resurveyed individuals who were previously exposed to information about a carbon tax appear to be less affected by negative news.

Such results support the inoculation theory, which states that exposure to related information prior to being exposed to arguments surrounding climate change will allow individuals to be less affected by future arguments or information related to climate change, as discussed by McGuire (1970), Compton *et al.* (2021), and others. Hence, resurveyed individuals who had prior exposure to information related to a carbon tax show higher climate concern relative to newly surveyed individuals and thus a greater level of acceptance of a carbon tax.

[13]The individuals surveyed in the first-round of the *Main survey* did not show significant differences in their acceptability in the *Resurvey*, which took place three months later.

TABLE 11— DIFFERENCES IN ACCEPTANCE BETWEEN THE *NEW SURVEY* AND THE *RESURVEY*

		(1) Pre-Survey Acceptance	(2) Pre-Survey Acceptance	(3) Climate Concern
Revenue Use	Tax Reduction	-0.023 (0.075)	0.005 (0.075)	-
	Lump-sum Transfers	-0.197** (0.083)	-0.212** (0.083)	-
	Green Projects	-0.011 (0.083)	-0.025 (0.084)	-
Gender		0.084 (0.055)	0.030 (0.056)	0.211*** (0.056)
Education		0.210** (0.082)	0.206** (0.082)	0.022 (0.082)
Age		0.000 (0.003)	0.000 (0.003)	0.002 (0.003)
Household Income		0.016 (0.060)	-0.009 (0.060)	0.008 (0.061)
Married		-0.090 (0.090)	-0.080 (0.090)	-0.079 (0.090)
Child		0.195** (0.077)	0.182** (0.077)	0.102 (0.077)
Location		0.082 (0.056)	0.079 (0.056)	0.022 (0.056)
Religion		0.006 (0.057)	0.001 (0.057)	0.062 (0.058)
Politics		-0.069*** (0.008)	-0.062*** (0.008)	-0.044*** (0.008)
Climate Concern		-	1.122*** (0.099)	-
Resurvey		-0.162 (0.062)	-0.155** (0.062)	-0.448*** (0.063)
Cutoffs		✓	✓	✓
Sample Size		1,400	1,400	1,400
Pseudo R^2		0.0152	0.0333	0.0150

Note: *, **, and *** correspondingly represent significance at the 10%, 5%, and 1% levels, and ( ) is the standard error.

V. Conclusion

Although imposing a price on carbon is considered to be the most economically efficient policy to reduce GHG emissions, many jurisdictions have failed to introduce a carbon tax, or the price was not high enough to encourage reduction due to public support. Thus, it is crucial to question how social acceptance for a carbon tax can be improved.

This paper conducted a survey experiment to analyze changes in social acceptance levels for a carbon tax depending on the use of the revenue and the types of information provided. First, public support can be changed depending on the use of the revenue. In general, lump-sum transfers have negative impacts on social acceptance for a carbon tax. Moreover, the impact of revenue use on social acceptance can vary with the level of climate concern; with low climate concern, tax reductions have a positive impact, while with sufficiently high climate concern, tax reduction and lump-sum transfers are likely to have negative impacts. On the other

hand, green project investments do not have a negative effect on support for a carbon tax, even at different levels of climate concern.

Second, information provision increases support, but no significant differences in the effect of different information types were observed in the full sample. This implies that differences in support across different revenue uses may remain the same, even after certain interventions, such as the provision of information. Thus, differences in support across different revenue uses should be considered in advance when introducing a carbon tax. Moreover, when the policy design and information type are consistent with the aim of the policy, the information effect can be amplified.

Once discussions concerning a carbon tax implementation intensify, individuals will be exposed to other information not included in the surveys. This may have an impact on the interaction effect of revenue use as described above and on information provision; nevertheless, the order in which information is provided remains important. Rabin and Schrag (1999), Wilson (2014) and others studied the potential for confirmation bias, showing that the order in which an individual receives various types of information has an impact on their decision-making process. Under these circumstances, the initial information received plays a significant role in their decision-making process. This type of interaction effect can be utilized by first providing information aligned with the policy's objective when implementing a carbon tax. Hence, there is a need to provide information related to the estimated GHG emissions reduction effect and the estimated environmental and economic value that follows.

APPENDIX

A. *Basic Description of a Carbon Tax*

As concerns about climate change continue to grow and efforts to reduce greenhouse gas emissions become more global, the implementation of a carbon tax has been discussed in Korea.

A carbon tax internalizes the cost of greenhouse gas emissions, providing an incentive to reduce emissions and improve economic efficiency. Setting a price for greenhouse gas emissions increases the cost of fossil fuels, which release a large amount of carbon, and promotes the use of renewable energy and high-efficiency appliances.

The implementation of a carbon tax may result in an increase in electric charges or gas bills. For example, if the tax rate is ₩30,000/tCO_2e, the average household's monthly electric charges could increase by ₩3,158, depending on the amount of electricity used.

B. *Control Group* (P_0)

Concerns surrounding climate change have gradually increased. To reduce greenhouse gas emissions and tackle climate change, a carbon tax can be implemented to set a price for carbon, which may make fossil fuels more expensive.

C. *Tax Reduction* (P_1)

There is concern that the implementation of a carbon tax will increase overall taxation. However, the revenue generated from a carbon tax can be used to reduce labor income taxes and consumption taxes, which can improve not only environmental performance but also economic performance by improving the distortionary tax system.

D. *Lump-sum Transfers* (P_2)

There is concern that the implementation of a carbon tax may have a negative impact on income distribution, especially for low-income households. However, the revenue generated from a carbon tax can be used to provide lump-sum transfers, which can be distributed equally among all households to mitigate the increased burden on low-income households.

E. *Green Project Investment* (P_3)

If the revenue from a carbon tax is used for green project investments, the impact of the tax on emissions reduction can be maximized. By using the revenue for R&D investments and to offset energy transition costs, beneficial long-run effects on

emissions reduction can be expected.

F. *Economic Value of Information* (I_1)

According to the Korea Meteorological Administration, typhoons and heavy rains caused economic damage amounting to 1.285 trillion won in 2020, which is more than three times the annual average of the damage from these disasters over the past ten years. Climate change increases production costs by damaging firms' production facilities, creating difficulties in the supply of energy and production inputs and negatively impacting agricultural productivity. These effects reduce the total agricultural production and increase farm prices.

The EU and the United States plan to implement what is known as a carbon border adjustment mechanism that imposes a carbon tariff on carbon-intensive products imported into their markets. As a result, the economic costs of greenhouse gas emissions will be increased for the steel and petrochemical industries.

In contrast, a survey of economists found that approximately 75% of people believe a carbon tax is the most efficient way to tackle climate change. Specifically, a carbon tax is more cost-effective than subsidies or a renewable portfolio standard.

Therefore, the implementation of a carbon tax can efficiently reduce greenhouse gas emissions and mitigate the economic damage caused by the transition to a low-carbon economy.

G. *Environmental Value of Information* (I_2)

According to the Korea Meteorological Administration, the average daily maximum temperature in June of 2020 was 28.0°C and the average daily temperature was 22.8°C. Both were the highest recorded since 1973. There were 2.0 heat wave days, which was also 1.4 days more than the average heat wave days in June.

Climate change raises sea levels, increases the frequency of natural disasters and abnormal weather, and has negative impacts on the global environment and ecosystems. According to the IPCC, the global average surface temperature has increased by approximately 1°C since the Industrial Revolution. If this trend continues and the increase exceeds pre-industrial levels by 2°C, a significant threat to the global ecosystem and civilization arises, as sea levels will rise and the arctic permafrost will melt.

Furthermore, 97% of climate scientists agree that humans are the cause of global warming. Human activities have increased greenhouse gas emissions by 70% from 1970 to 2004, leading to climate change.

Therefore, implementing a carbon tax can limit sea level rises and the environmental damage caused by natural disasters and abnormal weather.

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