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Predicting Changes in Transportation Usage and Reductions in CO_2 Emissions Due to Electric Cars

Sun Young Ahn*, **Sang Hyup Lee**

Korea Institute of Civil Engineering and Building Technology, Goyang-si, Gyeonggi-do, Korea
Email: *sy-ann@kict.re.kr

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Abstract

Reductions in CO_2 emissions have a significant effect on the transportation sector, and there is increasing interest in developing green cars such as electric cars. To prepare for the advent of the electric car era, it will be necessary to predict the increase in electricity demand owing to the spread of electric cars and determine the policy approaches. Therefore, the analysis was performed to promote the use of electric car that helps reduce CO_2 emissions. This study establishes a mode choice model using the stated preference method. To improve the predictive power of the model, some revealed preference data were also examined to consider the characteristics of the commuters and the extent of current electric car technology to determine and verify the parameters of the mode choice models. This was used to estimate changes in CO_2 emissions owing to the introduction of electric cars and present effective policy approaches to reduce CO_2 emissions.

Keywords

Electric Car, CO_2 Emissions, Stated Preference Survey (SP Survey), Mode Choice Models

1. Introduction

1.1. Study Background and Goals

Significant efforts are being made around the world to deal with the gradually worsening problem of climate change, and policies are being promoted at a national level such as specifying target countries for obligated greenhouse gas reductions. However, the greenhouse gas emission trends measured by the Ministry of the Environment from 2010 to 2015. Figure 1 shows that CO_2 emissions

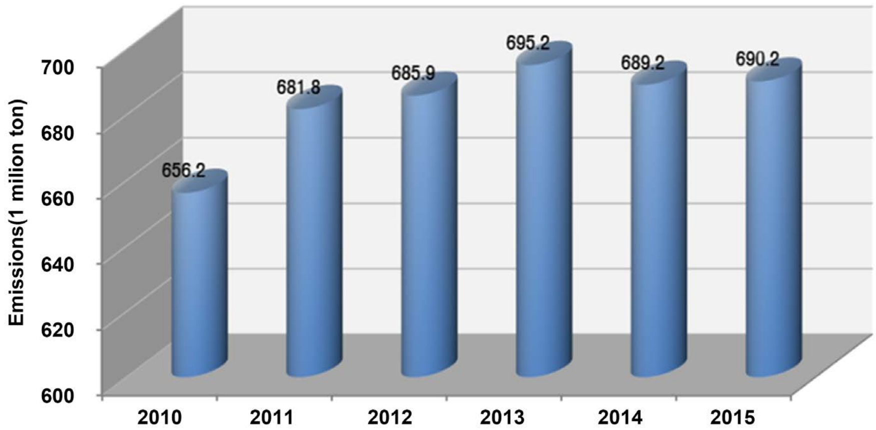

Figure 1. Greenhouse gas emission trends.

increased every year with the exception of 2014, and even in 2014, the range of reduction was very small [1]. Consequently, the government is studying policies that promote the spread of environmentally friendly cars such as electric cars, hybrid cars, and plug-in hybrid cars to reduce the CO_2 emissions caused by forms of transportation, and it is encouraging research related to the promotion of environmentally friendly cars. As such, a survey related to the policies and technological standards for electric cars currently being promoted was conducted in this study. The survey was used to estimate the usage ratios of cars, public transportation, and electric cars after the introduction of electric cars and to calculate the resultant changes in CO_2 emissions.

1.2. Study Methods and Procedures

In this study, the stated preference survey (hereon referred to as SP) method was used to predict the usage ratio of a new means of transportation, the electric car. An individual behavioral model was created based on the studied data with the goal of understanding factors that effect transportation mode choice and changes in usage ratios for each form of transportation, and calculating the change in CO_2 emissions owing to the introduction of electric cars. In addition, revealed preference (hereon referred to as RP) data were also collected and used to reflect individual characteristics in the construction of the model. Based on the collected data, the LIMDEP program, which is widely used for mode choice models, was employed to calculate the importance of each variable, *i.e.*, the parameter values.

2. Theoretical Observations

2.1. Transportation Modeling by Examining SP/RP

More studies have been conducted on potential factors affecting choice behavior since the 2000s [2] [3] [4] [5] [6]. The SP survey technique is a sequential technique that provides virtual scenarios to individuals about virtual situations that cannot be understood through surveys about real life in order to understand the individual's preferences and predict results. At the attribute level, each individual perceives a different utility for each choice, and the survey results can capture this perception according to whether or not a preference was chosen in the survey process [7] [8].

Electric cars have not created a market scale sufficient for the study of consumer preferences, and hence, it is necessary to study their choices in virtual scenarios to recreate the process of an individual selecting a form of transportation, and to select important characteristics and set rational standards for each characteristic [9] [10]. The implemented SP survey was used to analyze transportation behavior, and a Logit model was applied to estimate and verify the parameters. Thus, several variables that affect behavior were determined.

In estimating a behavioral model, RP data are data based on actual scenarios and behavior, whereas SP data are different in that they demonstrate preference decisions through virtual scenarios. As such, the two types of data can be observed to have mutually complementary qualities on a practical and statistical level. These are compared in **Table 1**.

2.2. Mode Choice Models via SP/RP Analysis

Hwang *et al.* [10] used SP surveys to compare preferences related to conventional cars according to the support for environmentally friendly cars and predicted the effect on policy alternatives. They also presented policy alternatives for promoting the spread of environmentally friendly cars and analyzed global automotive reform plans in terms of CO_2 emissions.

Lee *et al.* [11] used the SP survey method to analyze the demand for a new form of transportation called LRT (light rail transit). Accordingly, they created an individual behavioral model to understand changes in transportation demand for each form of transportation and to evaluate transportation policies.

Kim *et al.* [12] used SP surveys to analyze the demand for changes from a passenger car or bus to the city subway according to changes in fees and wait times in the Daejeon Metropolitan City subway, which will operate in the future. They collected and analyzed several forms of RP and SP data, including an external feasibility analysis of the mode choice models using SP data, in order to construct a disaggregated transportation model. In addition, application plans were examined via utility and future demand estimation models.

Table 1. Survey items and analysis content.

Type	RP	SP
Information	The results of actual behavior and choices The same as actual behavior Data that only have the results of actual choices	Expression of intentions in virtual scenarios Possibly will not match selection behavior Selection/Ranking/Grading data
Alternatives	Alternatives that actually exist	Includes alternatives that do not exist
Properties	Limited range of property values Correlation between properties exists	Expandable range of property values Controllable correlation between properties

Kim *et al.* [13] used SP surveys to select a general senior-friendly car and calculated the future replacement demand for it in each income class through analysis of the purchase replacement rate. Accordingly, the future market created by the development of a senior-friendly car was predicted, and its economic ripple effects on the country and other industries were predicted according to growth rate scenarios.

As the electric car choice percentage of the respondents varies according to their circumstances, this study constructs a mode choice models that combines RP and SP data while considering the social and economic characteristics of the individuals and the commute times and costs of various forms of transportation. Accordingly, this study examines the factors affecting mode choice and the usage rates for each form of transportation, and it calculates changes in CO_2 emissions owing to the introduction of electric cars.

3. Survey Content

3.1. SP Questionnaire Creation

The questionnaire presented in this study was created using an experiment design method for ensuring orthogonality between the properties of the virtual alternatives proposed to the survey respondents and avoiding multicollinearity, which is a problem in RP data.

When an experiment is set up with three properties at three possible levels and five properties at two possible levels, related to a total of 8 factors as in this study, there will be 576 experimental combinations. In this kind of multi-factorial survey, detailed information about interactions between factors can be obtained aside from the major effects. However, the experiment is performed more than once to combine the levels of all factors, and hence, the number of experiment rounds becomes greater in proportion to the number of factors. An increase in the number of experiment rounds leads to time and cost problems, and problems with making the combinations of factors and levels uniform when selecting alternatives. Therefore, this study assumed that there is no interaction between factors and compressed the 576 combinations into 58 types of transportation conditions. The questionnaires were created so that five of the 58 transportation conditions were presented to a respondent using a random function. **Table 2** shows the outline of the SP questionnaire for creating the model of electrical cars in order to create the mode choice models.

3.2. SP Survey Level Settings

In the SP survey, the commute time, commute cost, and parking cost levels for each form of transportation were set as shown in **Table 3**. The three levels of commutes were set under 60 min to reflect the fact that the daily average commute distance of a passenger car in the Seoul area is 34 km, including both ways, and the daily average commute speed of a passenger car is approximately 40 km/h. For setting the commute time of an electric car, its driving speed was set

Table 2. Survey items and analysis content.

Survey Items	Content
Individual and household characteristics	Age, sex, student status, number of household members, possession of driver's license
Conditional mode choice intention survey	Choice of a form of transportation mode under 8 conditions, assuming that a passenger car, public transportation, and electric car can all be selected
RP	The transportation mode selected for actual commute and time spent
SP	The transportation mode selected in a survey of five questions given to a person based on an orthogonal matrix table, which classifies transportation as a passenger car, public transportation, or electric car and places its related properties on 2 levels or 3 levels

Table 3. Factors and levels for each form of transportation.

Form	Factor for Each Form of Transportation	Unit	Level		
			1	2	3
Passenger Car	Commute Time	Minute	15	30	60
	Commute Cost	Won	4000	8000	-
	Parking Cost	Won	0	2000	-
Public Transportation	Commute Time	Minute	50	120	-
	Commute Cost	Won	1000	2500	-
Electric Car	Commute Time	Minute	30	60	90
	Commute Cost	Won	3000	6000	-
	Parking Cost	Won	0	1000	2000

at 1/2 or 2/3 of the speed of a passenger car to reflect the limited driving speed of the former. The commute cost reflected the cost of purchasing the car and the cost of filling up on fuel. In the case of a passenger car, this corresponded to gas costs (gas cost and filling time cost), whereas in the case of an electric car, this corresponded to charging costs (electricity cost and charging time cost). The cost of filling up on fuel for an electric car was far lower than that of a passenger car, but the cost of purchasing an electric car was large compared with fuel costs in an absolute sense, even when considering subsidies, and hence, this was reflected in the settings.

In the case of parking cost, it was decided that an economic incentive must be provided for the environmental friendliness of the electric car and hence, the cost was set at 1/2 that of the passenger car. For public transportation, the levels were set to reflect the current fees of normal buses and wide-area buses.

4. Survey Data Analysis

4.1. Individual Characteristic Data Analysis

In this survey, the personal characteristics such as age, sex, occupation (student or not), number of household members, and possession of a driver's license were the basic items of the survey. Table 4 shows the analysis results from the individual characteristics portion of the survey data. There were 100 respondents, with 20- to 30-year-olds accounting for the largest proportion at 85%. Further, 57% of all respondents were men, and 80% were students; 79% lived in households with two or more people, and 74% had a driver's license.

The survey analyzed the current transportation mode choice percentages according to the commute distance to understand the current situation. The analysis results are shown in Figure 2. The percentage of respondents selecting public transportation tended to be far higher than those selecting a passenger car, but this is believed to be because 80% of the respondents were students. As the commute distance increased, the percentage of respondents selecting a passenger car increased, except when the commute distance was 20 km or less. It is believed that this is because the respondents with a commute time of 20 km or less felt they spent a relatively large portion of their commute time reaching public transportation.

4.2. Transportation Mode Choice Intention Survey Analysis

In this survey, eight transportation intention survey items were presented. As shown in Table 5, these included two items related to parking cost conditions, three items related to driving distance limits, and three items related to the charging cost of an electric car. The respondents selected from among the three forms of transportation under each of the conditions assuming that all choices were possible without any real-world restrictions.

Figure 3 shows the transportation mode choice percentages for each case. Cases 1 and 2 are related to the parking costs. When the parking cost of an electric car was 50% that of a passenger car, the selection percentage of an electric car was 32%, but when the parking cost was zero, the percentage increased dramatically to 68%. Cases 3 - 5 are related to driving distance limitations. When the limitation in the driving distance per charge of an electric car was less, the selection percentage increased from 10% to 40% to 76%, whereas those of a passenger car and public transportation decreased. Cases 6 - 8 are related to the charging cost of an electric car per kilometer. As the cost became lower compared

Table 4. Results of survey on individual characteristics.

Age		Sex		Occupation	
20 - 30 years	85%	Man	57%	Student	80%
31 - 40 years	6%	Woman	43%	Worker	17%
40+ years	9%			Other	3%
Number of Household Members			Driver's License Possession		
Alone	21%		Has license	74%	
Two or more	79%		Does not have license	26%	

Table 5. Transportation mode choice intention survey items.

Survey Item	Content
Case 1	When the parking cost of an electric car is 50% that of a passenger car
Case 2	When the parking cost of an electric car is free
Case 3	When the maximum driving distance of an electric car is 50 km per charge
Case 4	When the maximum driving distance of an electric car is 100 km per charge
Case 5	When the maximum driving distance of an electric car is 200 km per charge
Case 6	When the charging cost of an electric car per km is 1/2 that of a passenger car
Case 7	When the charging cost of an electric car per km is 1/5 that of a passenger car
Case 8	When the charging cost of an electric car per km is 1/10 that of a passenger car

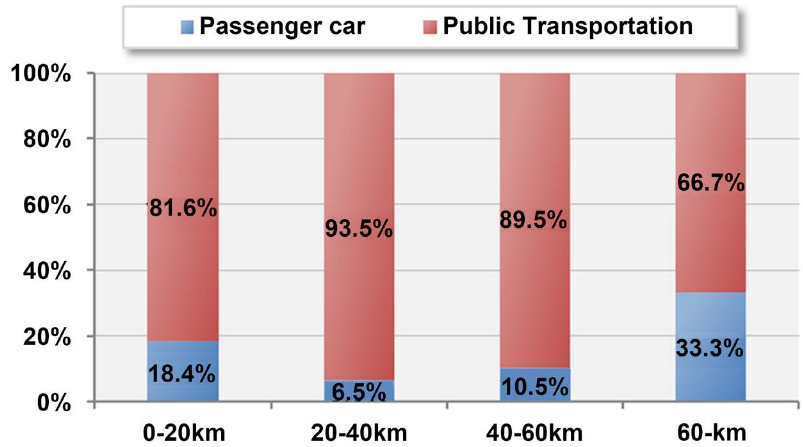

Figure 2. Mode choice percentage according to commute distance.

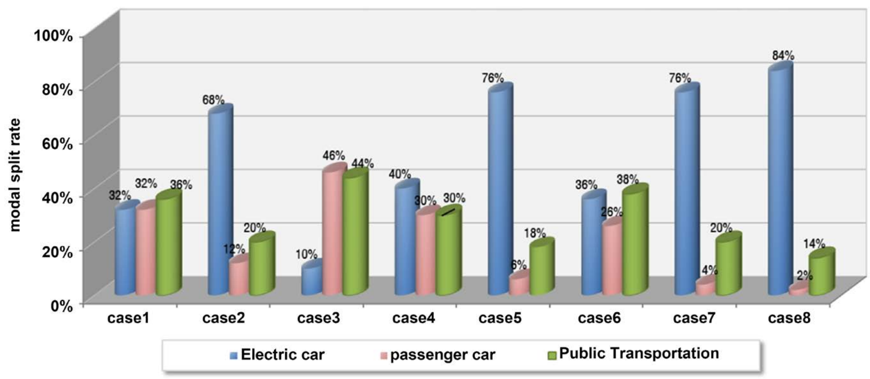

Figure 3. Transportation mode choice percentages by case.

with that of a passenger car, the selection percentage of an electric car increased from 36% to 76% to 84%, whereas those of a passenger car and public transportation decreased.

In this survey, the current commute characteristics of the respondent were divided into commute distance, commute time, and commute purpose. The results of analyzing the commute characteristics are shown in **Table 6**. Out of the 100

Table 6. Survey data according to commute characteristics.

Commute Time		Commute Distance		Commute Purpose	
0 - 30 min	23%	0 - 20 km	38%	To work	22%
30 - 60 min	20%	20 - 40 km	31%	To school	64%
60 - 90 min	15%	40 - 60 km	19%	Other	14%
90 - 120 min	30%	>60 km	12%		
>120 min	12%				

respondents, a majority had a commute of 0 - 20 km or 20 - 40 km, accounting for 38% and 31% of respondents, respectively. The distribution of respondents according to commute time was relatively even, and 30% had a commute time of 90 - 120 min. With regard to the commute purpose, the highest percentage of respondents (64%) was commuting to school.

The transportation mode choice intention cases include parking cost cases, driving distance limitation cases, and charging cost cases. The cases were selected to best reflect the current status and technology of electric cars, and the selection percentages were analyzed according to commute characteristics. For the charging costs, the case with the greatest difference between a passenger car and an electric car and the case with the smallest difference between them were both analyzed.

In Case 1 (**Figure 4**), where it was assumed that the parking cost of an electric car was 50% that of a passenger car, the results were different according to the commute purpose; 50% of respondents who mainly commuted to work preferred an electric car, and 50% of respondents who mainly commuted to school preferred public transportation. This seems to be due to the difference in the forms of transportation already used by the respondents commuting to work and school.

With regard to commute distances, the largest percentages of respondents commuting 0 - 20 km and 20 - 40 km preferred public transportation, at 45% and 42%, respectively. As the commute distance became longer, fewer respondents selected public transportation, and the percentage of respondents selecting a passenger car or electric car increased. This seems to be related to an increased appreciation of commute convenience as the commute distance becomes longer.

With regard to commute times, the largest percentage (44%) of respondents commuting for less than one hour selected a passenger car, but as the commute times increased, the percentages selecting public transportation and an electric car gradually increased, whereas the percentage selecting a passenger car gradually decreased. It seems that this was because the commuters felt the burden of parking costs as the commute time increased.

In Case 4 (**Figure 5**), in which the maximum driving distance of an electric car with one charge is limited to 100 km, the largest percentage of respondents (45%) with a commute goal of going to work selected a passenger car. However,

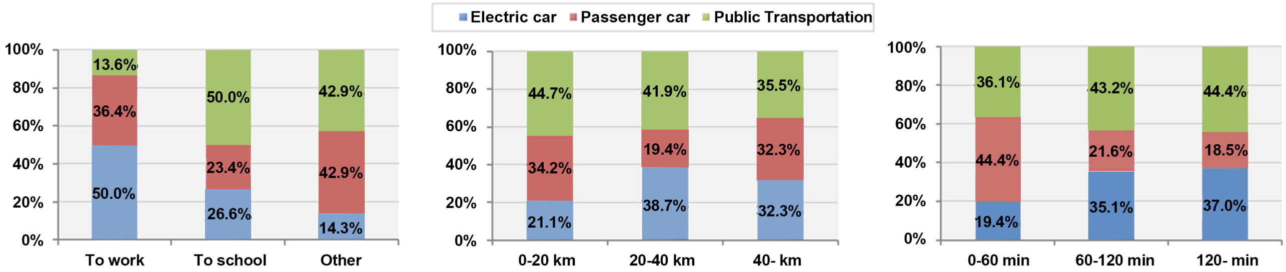

Figure 4. (Case1) Selection percentages according to commute purpose, distance, and time.

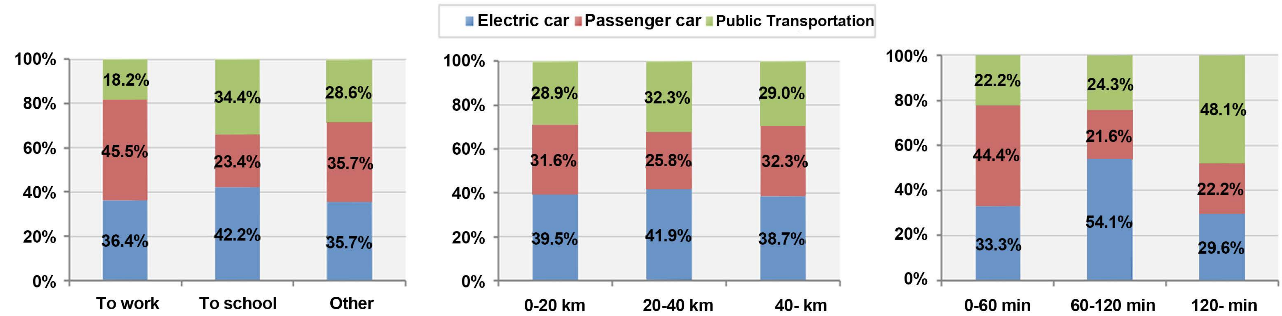

Figure 5. (Case 4) Selection percentages according to commute purpose, distance, and time.

when the purpose was going to school or another place, the selection percentages between the three forms of transportation were not significantly different. This seems to be because there is insufficient awareness of charging limitations and hence, responses were provided according to the commute purpose rather than the characteristics of the form of transportation or the given conditions.

Considering Case 4 by commute distance, there was no significant difference between the selection percentages of the three forms of transportation according to commute distance. This is believed to be because only 3% of respondents commuted 100 km or more.

Considering Case 4 by commute time, the largest percentage of respondents (44%) who commuted for one hour or less selected a passenger car. The largest percentage of respondents (54%) who commuted for one to two hours selected an electric car. The largest percentage of respondents (48%) who commuted for more than two hours selected public transportation.

In Case 6 (Figure 6), where it was assumed that the cost of charging an electric car per kilometer was 1/2 the fuel cost of a passenger car, the largest percentage of respondents (50%) with a commute goal of going to work selected an electric car. When this is compared with the fact that respondents going to work selected a passenger car as their most preferred form of transportation in the parking cost and driving distance limitation cases, it can be concluded that the respondents are more sensitive to the charging cost condition. The respondents whose commute purpose was going to school preferred public transportation most and an electric car second most, which were similar selection percentages as in the other cases. It is believed that this is because the choice of transportation

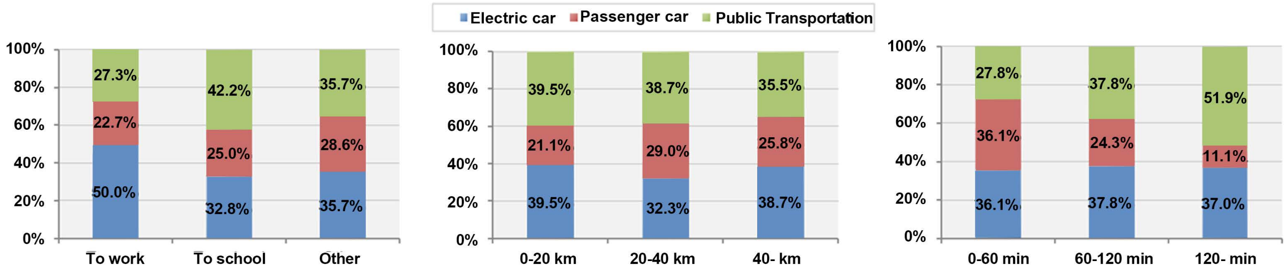

Figure 6. (Case 6) Selection percentages according to commute purpose, distance, and time.

for commuters who go to school is often limited to public transportation in reality.

Considering Case 6 by commute distance, there is almost no difference in the selected form of transportation of the respondents according to the commute distance. It is believed that this is because a difference in charging cost (fuel cost) has a small effect on inducing existing public transportation users to change their form of transportation, and passenger car users tend to emphasize convenience over sensitivity to charging cost.

Considering Case 6 by commute time, the respondents who selected an electric car showed no changes in their selected form of transportation according to commute time, but as the commute time increased, more respondents switched from a passenger car to public transportation. It is believed that this is because, as the commute time increased, the respondents an electric car.

In Case 8 (**Figure 7**), where it was assumed that the cost of charging an electric car per kilometer was 1/10 the fuel cost of a passenger car, most respondents selected an electric car regardless of their commute goal, and the percentage of respondents who selected a passenger car was zero with the exception of 3% of respondents who commuted to school.

Considering Case 8 by commute distance, a passenger car was not selected by any of the respondents except 3% of respondents commuting 20 - 40 km and 3% of respondents commuting 40 km or more. When respondents had a relatively short commute of 0 - 20 km, 24% selected public transportation, and 76% selected an electric car, but as the commute distance increased, more respondents preferred an electric car.

Considering Case 8 by commute time, a passenger car was not selected by any of the respondents except 3% of respondents commuting for one to two hours and 4% of respondents commuting for more than two hours. When the commute time was less than one hour, 11% of respondents selected public transportation, and 89% selected an electric car, and as the commute time increased, more respondents preferred public transportation.

It is believed that the overall analysis results of Case 8 were affected by the limitations in the size and characteristics of the survey group. However, it seems that the combination of commuting convenience and economic benefits provided by an electric car influenced the respondents, and it is believed that these conditions are the most appreciated by commuters.

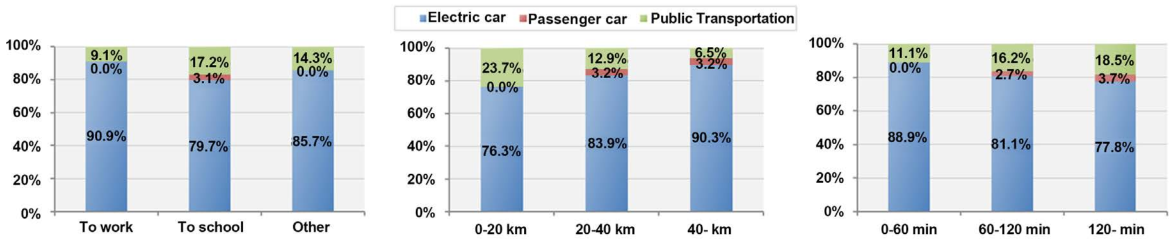

Figure 7. (Case 8) Selection percentages according to commute purpose, distance, and time.

4.3. Analysis of Transportation Mode Choice Percentages in RP and SP Data

This study used survey data related to transportation mode choice behavior regarding the current most frequently used transportation (RP) and the transportation mode choice behavior after by the introduction of an electric car (SP). Table 7 shows the transportation mode choice percentages for each type of data.

In the RP data, 85% of the 100 respondents were public transportation users, and this percentage was far greater than the percentage of passenger car users; however, this was because 80% of the respondents were students. In the SP data, each person was made to respond to five transportation mode choice questions, and hence, the total sample size was 500, and of these, the percentage of those selecting public transportation was the highest at 42.4%. The number of respondents selecting a passenger car and electric car were almost the same, but those selecting an electric car (29.60%) were slightly more than those selecting a passenger car (28.00%).

To create a model based on the survey data, the SP data, which simply add the new electric car form of transportation to a virtual situation, were not used by themselves. Instead, it was necessary to combine them with RP data, which reflect actual behavior slightly better.

5. Establishing an Analysis Model

5.1. Mode Choice Models

Selection behaviors were described by an expected utility maximization theory using a probability utility function. In the probability utility function U, individual characteristics and service variables are related. P_{ij}, Probability of an individual i selecting a mode j, is calculated by the following equation.

$$P_{ij} = \text{Prob}\left(U_{ij} > U_{ik}\right) \; k = 1,2,\ldots,j\left(k \neq j\right) \tag{1}$$

Prob ($U_{ij} > U_{ik}$)—the probability of $U_{ij} > U_{ik}$; U_{ij}—utility function of mode n for individual i; P_{ij}—probability of individual i selecting mode j;

By setting several variables in the utility function, several kinds of models for the cumulative distribution function of U_{ij} are determined. In this study, analysis was performed via the Log it model, and the equation of this model is as follows.

$$P_{ij} = \frac{\exp\left(U_{ij}\right)}{\sum_{i=1}^{I}\exp\left(U_{ij}\right)} \tag{2}$$

Table 7. Survey data according to commute characteristics.

Transportation Form	RP Data		SP Data	
Passenger Car	15	15%	140	28.00%
Public Transportation	85	85%	212	42.40%
Electric Car	-	-	148	29.60%
Total	100	100%	500	100%

$$U_{ij} = \sum_k a_k X_{ijk} \quad (3)$$

X_{ijk}—the value of the kth descriptive factor for mode j; I—total number of available transportation modes in the choice set for individual i.

5.2. Individual Characteristic and Mode Choice Characteristics Variables

Individual characteristic and mode choice characteristics variables were set based on the basic analysis results from the data examined in this study. Table 8 lists the variables that were set and content related to the variables. Among the individual variables, the age variable was a continuous value in the model, whereas the rest of the variables were either 0 or 1. Among the transportation variables, the variables related to commute time were continuous values in units of minutes, whereas the commute costs were continuous values in units of Won.

6. Analysis Model Estimation Results and Analysis

6.1. Analysis of Estimation Results According to Individual Characteristics and Mode Choice Characteristics

The model estimation results are shown in Table 9. The modified likelihood ratio ( ), which is an index of the fitness of the model, was satisfactory at 0.413. In addition, it was observed that the commute time, commute cost, and parking cost alternative characteristic variables were significant at a t-value confidence level of 95%, and it was confirmed that they have an influence on mode choice. Among the individual characteristics, possession of a driver's license affected mode choice, and sex had an effect on the choice of public transportation. As an individual characteristic observed to be significant at an 85% confidence level, age had an effect on the choice of public transportation. Status as a student and the number of household members did not have an effect on mode choice.

6.2. Calculating CO_2 Emissions According to the Analysis Model

Only significant variables were selected based on the model described in the previous section, and a newly estimated model, shown in Table 10, was used to calculate the CO_2 emissions in the Seoul area.

The basic units shown in Table 11 were used to calculate the CO_2 emissions. An average value of the basic units of buses, subways, and Seoul area subways

Table 8. Survey data according to commute characteristics.

Variable Type		Variable Value and Unit
Individual Characteristic Variables	Age	Years
	Sex	Man = 0, Woman = 1
	Occupation	Student = 0, Other = 1
	Number of Household Members	1 or less = 0, 2 or more = 1
	Driver's License Possession	Yes = 0, No = 1
Mode Choice Characteristics Variables	Commute Time	Minutes
	Commute Cost	Won
	Parking Cost	Won

Table 9. Model estimation results.

Variable			Estimated Value	t-value		*P*-value
Alternative Special Constant		Public Transportation	−0.1119	−0.103		0.9179
		Electric Car	−0.7598	−0.704		0.4815
Individual Characteristic Variables	Age	Public Transportation	0.0514	1.556	**	0.1197
		Electric Car	0.0262	0.807		0.4195
	Sex	Public Transportation	−0.7553	−2.349	***	0.0188
		Electric Car	−0.0521	−0.161		0.8723
	Occupation	Public Transportation	−0.6295	−1.122	*	0.2621
		Electric Car	0.1995	0.356		0.722
	Driver's License Possession	Public Transportation	2.0014	5.159	***	0
		Electric Car	0.7966	2.035	***	0.0418
	Number of Household Members	Public Transportation	0.1708	0.475		0.6351
		Electric Car	0.1894	0.486		0.6267
Alternative Characteristic Variables	Commute Time	Passenger Car	−0.0591	−6.659	***	0
		Public Transportation	−0.0521	−11.957	***	0
		Electric Car	−0.0596	−8.585	***	0
	Commute Cost	Passenger Car	−0.0005	−7.365	***	0
		Public Transportation	−0.0010	−5.427	***	0
		Electric Car	−0.0005	−5.589	***	0
	Parking Cost	All Forms	−0.0003	−3.084	***	0.002

Note: ***: *P*-value ≤ 0.05, **: *P*-value ≤ 0.15, *: *P*-value ≤ 0.30.

was used for public transportation. No specific basic unit for an electric car has been proposed yet, and hence, it was decided that it would be appropriate to use the basic unit of the KTX high-speed rail, which uses only electricity, from among the basic units shown in Table 11.

The standard values shown in Table 12 were specified in order to analyze the

Table 10. Survey data according to commute characteristics.

Variable		Estimated Value	t-value		*P*-value
Driver's License Possession	Public Transportation	1.5677	5.198	***	0
	Electric Car	0.6125	4.524	**	0.0862
Commute Time	Passenger Car	−0.0615	−7.638	***	0
	Public Transportation	−0.0468	−12.813	***	0
	Electric Car	−0.0607	−9.843	***	0
Commute Cost	Passenger Car	−0.0005	−9.897	***	0
	Public Transportation	−0.0008	−5.367	***	0
	Electric Car	−0.0005	−7.518	***	0
Parking Cost	All Forms	−0.0004	−3.415	***	0.0006

Note: ***: *P*-value ≤ 0.05, **: *P*-value ≤ 0.15.

Table 11. CO_2 emission units.

Form of Transportation	g·CO_2/person·km
Passenger Car	168.2
Bus	55.7
KTX	26.9
Saemaeul Train	66.4
Mugunghwa Train	42.3
Seoul Area Subway	26.5
Subway	25.9

Source: info.korail.com.

Table 12. CO_2 emission units.

Type	Time (Minutes)	Cost (Won)	Parking Cost (Won)	Driver's License Possession
Passenger Car	30	8000	2000	Yes
Public Transportation	90	2500	0	Yes
Electric Car	60	6000	1000	Yes

transportation usage rates and CO_2 emissions according to the changes in commute time, commute cost, and parking cost. In order to apply the basic units proposed by the Korea Railroad Corporation, analysis was performed based on the level of travel presented in the Seoul Area Household Travel Diary Survey, which stated that people in the Seoul area commuted 335,300,000 km in 2006. The results are shown below.

Figure 8 shows the results of commute time analysis, CO_2 emissions were reduced by 4398 tons when the commute time was reduced from 60 min to 30 min, and emissions increased by 1809 tons when the commute time increased by 30 min. From the changes in CO_2 emissions according to changes in commute

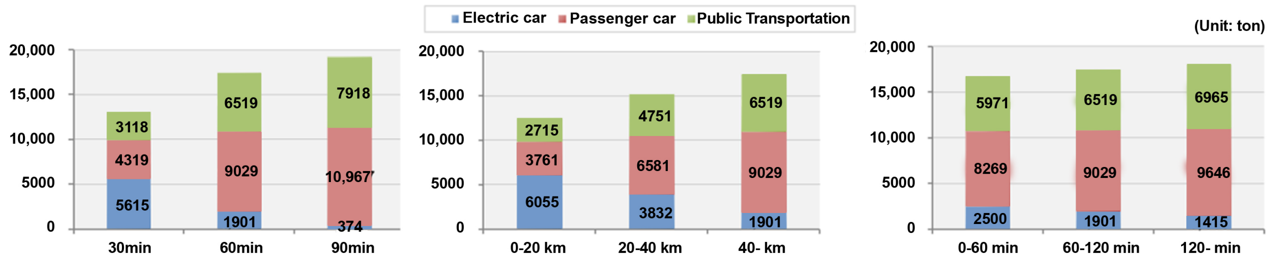

Figure 8. Changes in CO_2 emissions according to changes in commute time, commute cost, and parking cost.

cost, when the commute cost of an electric car was reduced by 2000 Won, emissions were reduced by 2286 tons, and when the commute cost was reduced by 4000 Won, emissions were reduced by 4919 tons. In addition, when the parking cost was reduced by 1000 Won, emissions were reduced by 709 tons, and when the parking cost was increased by 1000 Won, emissions increased by 576 tons.

7. Conclusions

The present study performed an SP survey regarding the introduction of an electric car and analyzed it to construct a model and predict the usage ratios for each form of transportation.

To reduce CO_2 emissions with the use of electric cars, it is necessary to develop technology that can reduce the commute times and introduce related facilities. In current electric cars, the maximum driving distance with a single charge is much shorter than that of a passenger car, and electric cars are not well regarded because of long charging times and inadequate charging facilities. In addition, while the actual fuel costs are much cheaper than those of a passenger car, the burden of purchase cost has a significant limiting effect on the use of electric cars. As such, in order to expand the supply of electric cars, the overall cost such as the cost of buying electric car and oil price should be considered. And based on economic analysis, appropriate government subsidies for electric cars must be arranged.

In this study, the survey was performed on a limited population where 80% of the respondents were students and 85% were in their twenties. Therefore, the population and its properties were biased, and the survey may have arrived at results that are not significant to users other than students. Therefore, in the future, it will be necessary to select a larger and more diverse population to perform research to calculate rates of change in transportation mode choice according to commute cost, time, distance, etc., and also calculate the extent of changes in CO_2 emissions in a more appropriate way in terms of the environment and policy.

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