A Proposal of Feed-in Tariff Personal Carbon Allowance (FIT-PCA) and its Evaluation

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Abstract: *Japanese energy and climate policy stands at a critical junction at present and we may need innovative policies from different approaches. The idea of personal carbon allowances (PCA) system is one of the innovative policies to surmount the issues. In this study, a new PCA system, feed-in tariff PCA (FIT-PCA), which main purpose is to improve their attitudes and behaviors to reduce CO_2 emission by their own management of their allowances, has been proposed and its public acceptance was evaluated. FIT-PCA has been designed based on three principles which are "simplicity", "fairness" and "effectiveness". When introducing a new policy, the public acceptance is always one of the difficult issues. Therefore, a questionnaire survey for the public acceptance of the proposed FIT-PCA was conducted on the Internet. In the survey, FIT-PCA was compared with a carbon tax policy. The result shows that FIT-PCA has a possibility to be accepted as well as the carbon tax, and they admire the potential ability to reduce the total CO_2 emissions by FIT-PCA. However, it was also revealed that individual factors such as place of residence and residential form sometimes cause feeling of unfairness. The compensation rules for the unfairness will be necessary when introducing FIT-PCA.*

Keywords: personal carbon allowances, public acceptance questionnaire survey.

1. INTRODUCTION

In order to reduce CO_2 emission in Japan, we may need innovative energy and climate policies such as imposing an economic burden or constraint for the CO_2 emissions from our daily lives. Under the Kyoto Protocol, Japan has pledged to reduce 6 percent of CO_2 emissions in 1990 by 2012. In order to reduce CO_2 emissions, Japanese government has encouraged use of nuclear energy because more than 80% of greenhouse gases are CO_2 emissions from energy source in Japan [1] and the nuclear energy does not emit CO_2 when generating electricity. However the Great East Japan Earthquake and the following accident at Fukushima Dai-ichi Nuclear Power Plants significantly damaged public trust in the safety of nuclear power [2]. Therefore, nuclear energy can be no longer expected to be relied on. Other renewable energies which do not emit CO_2 such as solar, wind, geothermal and biomass are still under development and they cannot be replaced with conventional thermal and nuclear energy because of their instability and inefficiency. In conclusion, it is necessary to change our energy policy dramatically, for example, introducing an innovative energy policy which imposes economic burden or constraint for the emission of CO_2 from our daily lives.

Personal carbon allowances (PCA) system is the policy in which the government distributes the right to emit CO_2 to citizens and manage them [3]. The PCA system has been studied mainly in the UK and it is expected not only to reduce CO_2 emissions but also to improve our environmental attitudes as a non-economic effect [4]. Japanese government however has no experience to manage CO_2 emission when using energy and has left our own managements to us. It is therefore difficult to adapt the research results in the UK directly to Japan.

In this study, a new PCT system, FIT-PCA, has been proposed, which distributes personal carbon allowance to citizens equally and they redeem it when they consume energy in their daily lives. The allowance can be sold to the government at a fixed price when it is sufficient and can be bought when insufficient. In this study, its public acceptance was also evaluated by a questionnaire survey on the Internet.

2. PROPOSAL OF FIT-PCA SYSTEM

Since the PCA systems studied in the UK and Nordic countries allow them to trade the allowance between themselves or in the market, the management effect of CO_2 emission is greatly affected by the price of allowance deals. In addition, the lives of the people who have to consume much energy may be pressured when the price becomes high. On the contrary, when the price becomes low, the motivation to reduce energy consumption and CO_2 emission may decrease. This instability may spoil the effect which improves their environmental attitudes and behaviors by managing their own CO_2 emissions.

In this study, therefore, Feed-in Tariff PCA (FIT-PCA) has been proposed which main purpose is to improve their attitudes and behaviors to reduce CO_2 emission by their own management of their allowances.

The FIT-PCA has introduced the idea of German feed-in tariff rule of electricity [5] and the government purchases and sells the remaining allowance at a fixed price. This prevents from reducing their motivation for CO_2 emission management caused by the price instability in the

conventional PCA systems and encourages the investment to housing equipment for reducing CO_2 emission because they can easily view their future energy consumption plan.

The amount of distributed allowances is determined based on the average of CO_2 emission from individuals because it is effective for the people who emit large amount of CO_2 to become aware of their own emissions in order to change their energy consumption behaviors.

2.1 Principles of FIT-PCA

FIT-PCA has been designed based on three principles which are "Simplicity", "Effectiveness" and "Fairness". These definitions and reasons will be described in the followings;

・Simplicity

FIT-PCA mechanisms must be comprehensive and the procedure must be simple. Because the ideas of imposing a constraint on CO_2 emissions is relatively new and current emission trading system is applied only to companies, it is unfamiliar to the public at present.

・Effectiveness

FIT-PCA should be effective for the citizens to improve their attitudes and behaviors to pro-environment. This is the main purpose of this policy. It is also expected to give a good influence to solve other social issues because its affected fields are broad.

・Fairness

FIT-PCA should not cause the feeling of unfairness because it is applied to various kinds of people who live various areas and situations such as ages, number of family members, climate of residential area and house forms, and these varieties affect the amount of CO_2 emissions. FIT-PCA needs compensatory rules to reduce such unbalance caused by the varieties..

2.2 Target category of CO_2 emissions

The target categories of CO_2 emissions in FIT-PCA are energy consumption of their daily lives such as electricity, gas, gasoline, light oil and heating oil. Because the majority of CO_2 emissions sources from modern society are energy consumption in Japan. In addition, the wide coverage policy such as RAPs [6] cannot be introduced at present because it also covers most of the commercial products and needs huge cost with its operation.

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2.3 System flow

Figure 1 shows the flow of FIT-PCA. (i) Government distributes free personal carbon allowance (PCA) to citizens periodically and equally. Here the PCA means how people have the right of CO_2 emission from their daily lives. (ii) People have to redeem the PCA when they purchase / consume energy such as electricity, gas, gasoline, light oil and heating oil which originate in fossil fuels. (iii) If they don't have enough PCA when purchasing the energy, they have to also purchase the shortage of PCA. (iv) They can sell the excessive PCA to the government at a fixed price if they don't need it. In this system, people have to manage their CO_2 emission by their energy consumption and it is expected not only that they reduce their energy consumption and CO_2 emission but also that it is expected to foster their pro-environmental attitudes and behaviors.

The PCAs which are distributed to children should be managed by their parents or protectors. And the transfer and integration of PCA inside the same household is allowed because the energy consumption of their daily lives can be managed only by their household units.

2.4 Distribution amount and period of PCA

The PCA is transferred to all the individual PCA accounts equally without charge at the beginning of each month. The amount is one-twelfth of decided annual amount decided based on the annual average of CO_2 emission per person. The account is allowed to be kept for 12 months including the distribution month (banking). The PCA which exceeds 12 months will be expired and disappears from the account. In this rule, the government would be able to prevent from the weakening of PCA management for banking after the next fiscal year.

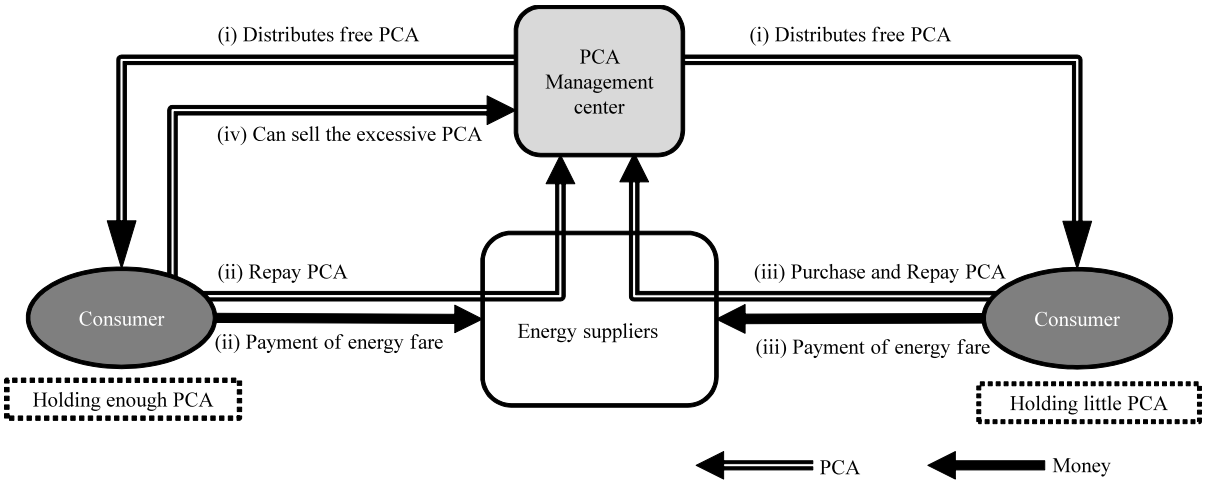


Fig. 1 Flow of FIT-PCA.

3. QUESTIONNAIRE SURVEY

3.1 Purpose

The FIT-PCA is still under development stage. The following knowledge on the FIT-PCA is required for its actual introduction.

・Image and support of FIT-PCA

In order to confirm the possibility to discuss it as one of the realistic policies, it is necessary to examine how the general public feels the FIT-PCA and how much they support it.

・Request of unfairness compensation

It is impossible to realize completely fair policy for all the citizens because they live in different areas in different forms. In order to bring it to be the "Fairness" principle by adding compensatory rules, it is necessary to examine what reasons they feel it unfair.

・Effect by being aware of the average line

For the principle "Effectiveness" of FIT-PCA, it is necessary to confirm the effect that they are aware of the difference between their own CO_2 emission and the average line. It is expected that the people whose emission exceeds the average especially become to have strong motivation to reduce their CO_2 emission.

3.2 Outline of survey

A questionnaire survey was conducted by using an Internet-based questionnaire service provided by Japanese largest market research company. The survey term was four days from December 22nd to 26th in 2011. The number of valid responses was 1,027. Table 1 shows the number of the valid responses under each condition. The reason why the conditions were set as shown in Table 1 was to avoid maldistribution of the respondents. The energy consumptions of condominiums are expected to be less than that of detached houses, and number of family members may affect the consumptions[6]. The residential areas also affect the energy consumption in Japan because they need heavy heating system in cold winter especially in north areas. And the capital Tokyo has 13 million population and they may not need their own cars because it has advanced public transportation system. Therefore the residential areas of the respondents were divided into four categories in this survey which are Hokkaido (cold area), south Japan (hot areas, Kagoshima, Miyazaki and Okinawa), Tokyo (metro) and other areas.

At present, Japan has not introduced the policy which directly gives an economic burden or restriction of CO_2 emission to individual citizens, so that the respondents may not be able to image the FIT-PCA. In the survey, therefore, an imaginary carbon tax policy was given as well as the FIT-PCA policy and they answer the image and support of FIT-PCA by comparing it with the carbon tax. Figure 2 shows the diagrams of the FIT-PCA and the carbon

Table 1 Number of the valid responses

	Cold area (Hokkaido)	Hot area (South Japan)	Metro (Tokyo)	**Other areas**	**Total**
Male	**54**	**53**	**52**	**347**	**506**
Detached house	26	26	26	174	252
Cluster house	28	27	26	173	254
Female	**49**	**51**	**53**	**368**	**521**
Detached house	24	26	27	187	264
Cluster house	25	25	26	181	237
Total	**103**	**104**	**105**	**715**	**1027**

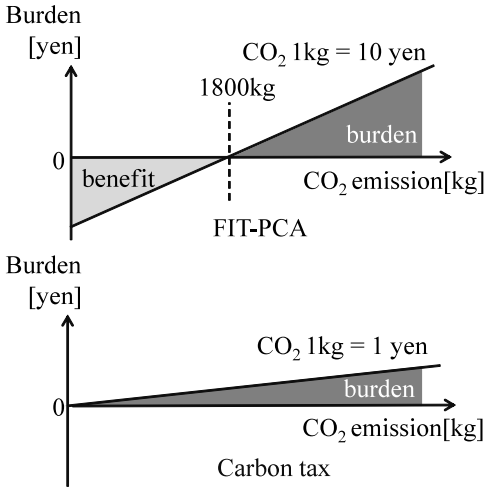


Fig. 2 Schematic diagrams of FIT-PCA and carbon tax.

Table 2 Support rate of FIT-PCA

	Cold area (Hokkaido)	Hot area (South Japan)	Metro (Tokyo)	**Other areas**	**Total**
Male	**55.5%**	**71.6%**	**50%**	**59.3%**	**59.2%**
Detached house	57.6%	69.2%	46.1%	56.8%	57.1%
Condominium	53.5%	74.0%	53.8%	61.8%	61.4%
Female	**67.3%**	**50.9%**	**58.4%**	**60.3%**	**61.8%**
Detached house	70.8%	50.0%	55.5%	60.4%	59.8%
Condominium	64.0%	52.0%	61.5%	65.7%	69.1%
Total	**61.1%**	**61.5%**	**54.2%**	**61.2%**	**60.5%**

tax. In this survey, the rate of the carbon tax was set to 1 yen per 1 kg CO_2 emission while the fixed price of the FIT-PCA was 10 yen per 1 kg. The PCA distributed by the government was assumed to be 1,800kg per person per year.

3.3 Result: image and support of FIT-PCA

Table 2 shows the support rate of FIT-PCA under various conditions. The total support rate was 60.5%. In this survey, the questions about "Simplicity", "Effectiveness" and "Fairness" of FIT-PCA were also given in order to examine how these factors affected the support rate. In addition, these questions were given before and after calculating their own CO_2 emissions a year in order to collect both their general and detail opinions. Figure 3 shows the results of the analyses of correlation and multiple linear regressions. After calculating their CO_2

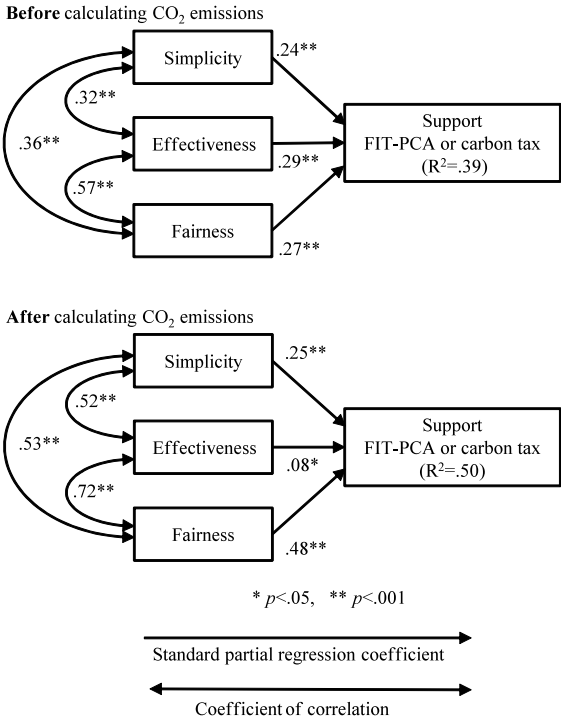


Fig. 3 Path diagram of policy support and principles.

emissions, the standard partial regression coefficient of "Fairness" became obviously high. This change may be caused because they recognized their own CO_2 emissions and noticed that CO_2 emission was depending on their individual residential situations.

3. 4 Result: request of unfairness compensation

In the questions about unfairness of FIT-PCA, several selections of the reasons were given to the respondents and they chose ones which they feel as unfair factors. Table 3 show the number of the chosen unfair factors.

Table 3 Number of the chosen unfair factors

Unfair factor	n
Difference of the climate	498
Undevelopment of public transportation system	422
Number of household members	416
Detached houses	268
Without children	218
Nothing unfair	171
Others	37

The first unfair factor they felt was the difference of the climate of the residential areas, and the second was the development of public transportation system, and the next was number of household members.

In order to discuss the relationship between their feeling of unfairness and their residential conditions, the relationship between CO_2 emissions from each energy sources and their residential conditions was examined. Figure 4 shows the path diagram of CO_2 emissions from residential conditions. As the result of multiple regression analysis, it was found that the gas consumption was the most related to the amount of CO_2 emission. The second related factor was electricity consumption which was also affected by the number of household members. The third was gasoline, while the forth was heating oil which was heavily consumed in cold areas such as Hokkaido. This might cause the unfair feeling of people especially living in cold area.

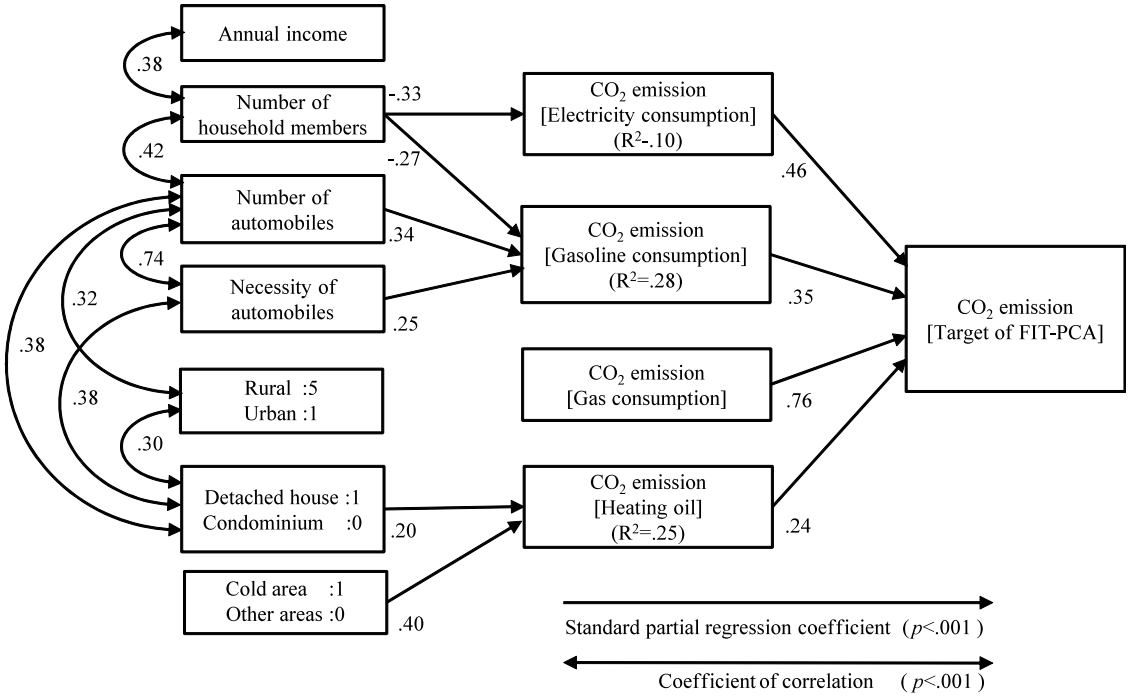


Fig. 4 Path diagram of CO_2 emissions from residential factors.

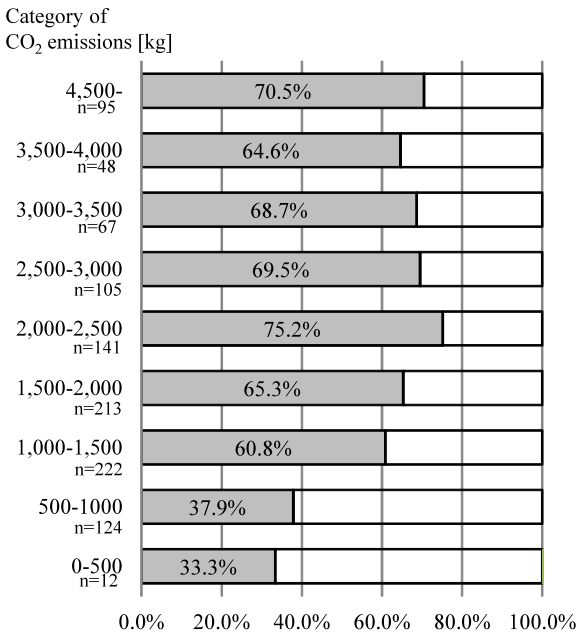


Fig. 5 Rates of respondents who had an intention of CO_2 emission reduction.

3. 5 Result: effect by being aware of the average line

One of the aims of FIT-PCA system is to improve their motivation of CO_2 emission reduction by comparing their own emissions with the average. Figure 5 shows that the rates of respondents who had an intention of CO_2 emission reduction categorized into their total amount of CO_2 emission calculated in this survey. It is not obvious that the respondents whose emissions were more than 2,000kg (average of Japanese citizen) had the intention. The authors therefore examined the difference between the groups categorized by the amount of CO_2 emissions. Table 4 shows the results of the chi-square test. As the result, it was found that there was significant difference between 1,500-2,000 kg per person per year group and 2,000-2,500 kg group (χ^2=3.917, df = 1, p<.05).

In order to examine the effect by being aware of the average line, the relationship between the intention and their senses of value was analyzed. In the questionnaire, 11 senses of value were asked to the respondents in 5 grade Likert scale, which were assumed to affect the consciousness of CO_2 emissions.

In order to reveal the influence structure between their senses of value and consciousness of CO_2 emissions, the mean values and standard deviations of the answers of these questions were first calculated. Then after confirming the no ceiling effect was shown in each answer, a factor analysis was conducted by maximum likelihood method.

As the result considering the eigenvalue change (3.37, 1.46, 1.25, 1.08, 0.70, 0.65, 0.62, …) and their interpretation, four main factors were found. Therefore, a factor analysis assuming the four factors was conducted again by maximum likelihood method and promax rotation. Table 5 shows the correlations

Table 4 Results of chi-square test

Category of CO_2 emissions [kg]	Chi-square value	Judge
4,500 - 3,500 - 4,000	0.205	*n.s.*
3,500 - 4,000 3,000 - 3,500	0.118	*n.s.*
2,500 - 3,000 2,500 - 3,000	1.207	*n.s.*
2,000 - 2,500 1,500 - 2,000	3.917	*
1,500 - 2,000 1,000 - 1,500	0.854	*n.s.*
1,000 - 1,500 - 1,000	18.673	**

df = 1, *n.s* : not significant, * p <.05, ** p <.01

between each factor and the final factor patterns after the promax rotation. The ratio to explain the variances of all the 11 answers before the promax rotation was 65.1%.

Since the first factor consists of five items such as interest of future of society, global environment issue and politics, it was named “interest in public”. The second factor consists of four items such as attention to belongings, preference for new things and desire to be recognized from others. It was named “desire for fulfillment”. The third factor has only one item which is preference to manage household account. It was named “desire for household management”. The forth factor consists of two items which are careful and long use of products and self-awareness of frugal person. It was named “frugal mind”.

The averages and standard deviations of the items which had high load value were calculated as the score of each factor. “interest in public” score is (average 2.50, SD 0.67), “desire for fulfillment” score is (average 2.39, SD 0.63), “desire for household management” is (average 3.01, SD 1.32) and “frugal mind” score is (average 2.14, SD 0.74). In order to examine the internal consistency between plural items in a factor, Cronbach α was calculated except “desire for household management” which has only one item. As the result, the score of “interest in public” is α=.74, that of “desire for fulfillment” i s α=.67 and that of “frugal mind” is α=.60. Although the score of “frugal mind” is relatively low, it was not rejected because the factor load was enough high as well as other factors.

In order to examine the difference between high CO_2 emission group and low emission group, the respondents were classified into two groups. The respondents whose CO_2 emissions were more than 2,100kg per person per year were classified into a “over 2,100kg” emission group, while those less than 1,900kg were “less than 1,900kg” group. The respondents whose emissions were between 1,900kg to 2,100 kg were omitted because it was very close to the average CO_2 emission. As the result of significant difference analysis between these two groups, it was

Table 5 Correlation between the final factor patterns of thinking or characteristic factors

Internal factors	‡ T	‡ U	‡ V	‡ W
Interest of future society	**.82**	.02	-.05	.04
Interest of grobal environment issue	**.76**	-.07	.06	.04
Interest of politics	**.52**	.06	-.10	.07
Interest neighborhood association	**.45**	-.04	.21	-.08
Attention to belongings	-.11	**.67**	.03	.12
Preference for new things	.08	**.65**	.00	-.23
Desire to be recognized from others	-.02	**.50**	.02	.17
Seek a nice life	**.39**	**.39**	.00	.01
Preference to manage household account	.01	.04	**.99**	.02
Careful and long use of products	.00	.08	-.08	**.70**
Self-awareness of frugal person	.07	-.08	.12	**.61**

Factor correlation matrix	‡ T	‡ U	‡ V	‡ W
‡ T	-	.37	.17	.40
‡ U		-	.12	.29
‡ V			-	.20
‡ W				-

Table 6 Cross-correlation of all respondents

	‡ T	‡ U	‡ V	‡ W	‡ X
‡ T	—	.41**	.24**	.35**	.21**
‡ U		—	.17**	.22**	.13**
‡ V			—	.22**	.02
‡ W				—	.08*
‡ X					—

* p <.01, ** p <.001
‡ T Interest in public
‡ U Desire for fulfillment
‡ V Desire for household management
‡ W Frugal mind
‡ X Intention of CO2 emission reduction

Table 7 Cross-correlation of "over 2,100kg" and "less than 1,900 kg"

	‡ T	‡ U	‡ V	‡ W	‡ X
‡ T	—	.43**	.19**	.31**	.22**
‡ U	.38**	—	.16**	.26**	.09*
‡ V	.27**	.14**	—	.19**	.02
‡ W	.34**	.15**	.25**	—	.09
‡ X	.21**	.17**	.01	.09*	—

* p <.01, ** p <.001
‡ T Interest in public
‡ U Desire for fulfillment
‡ V Desire for household management
‡ W Frugal mind
‡ X Intention of CO2 emission reduction

Upper right: over 2,100 kg group
Under left : less than 1,900 kg group

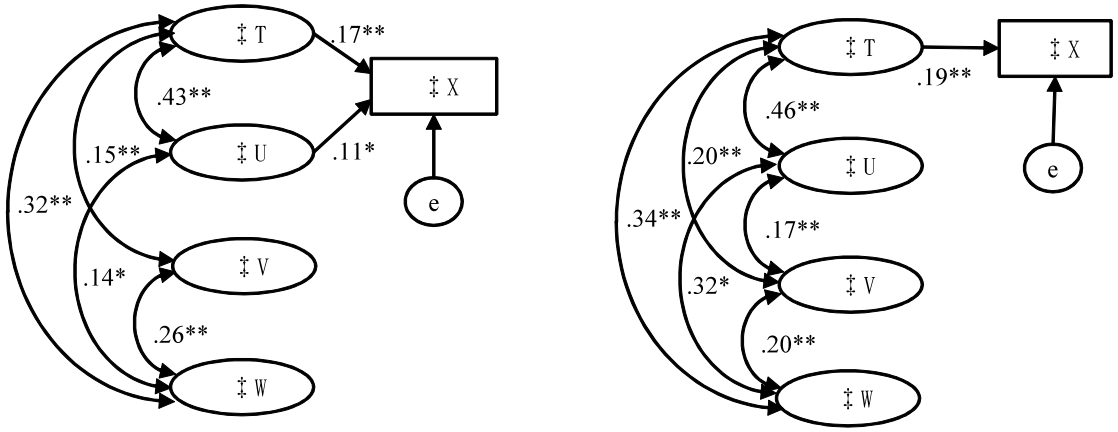
found that only the factor "frugal mind" had significant difference (p<.05). This means that the respondents who emit less than 1,900kg CO_2 has higher "frugal mind" than those of more than 2,100kg. The cross-correlation between the four factors and their intention of CO_2 emission reduction after recognizing their own emissions were calculated by using a dummy variable. Table 6 shows the result of all the respondents, while Table 7 shows that of "over 2,100kg" and "less than 1,900kg" groups.

Next, in order to examine the influence between the four factors and their intention of CO_2 emission reduction after calculating their own emissions, multiple regression analyses were conducted separately according to their CO_2 emissions. Figure 6 shows the path diagrams of "over 2,100kg" and "less than 1,900kg" emission groups based on the result of the analysis. The correlation coefficients between four factors are also noted in Figure 6. As the result, the standard partial regression coefficient from "interest in public" and "desire for fulfillment" to the intention of CO_2 emission reduction was significant in "less than 1,900kg" group. On the other hand, only that from "interest in public" was significant in "over 2,100kg" group.

In the same way as the above, the respondent groups whose emissions are 1,500-2,000kg and 2,000-2,500kg were also analyzed. As the result of difference analysis between these two groups, there was no significant difference of the four factors. As the result of multiple regression analysis, there was a significant relationship from "interest in public" to the intention of CO_2 emission reduction in both groups. Figure 7 shows the path diagrams of this analysis results.

As the results mentioned above, the respondents who were interested in public concern tended to reduce their CO_2 emission when they recognized their own CO_2 emission regardless of their amounts. However, it was also found that the 2,000-2,500kg group respondents had higher intention of CO_2 emission reduction than 1,500-2,000kg group.

The respondents whose emissions were less than the average have less intention of emission reduction, however, those who have "interest in public" and "desire for fulfillment" tend to have the intention. It was also found that the factors "desire for household management" and "frugal mind" does not affect the intention.



< Less than 1,900 kg group >
(n = 526)

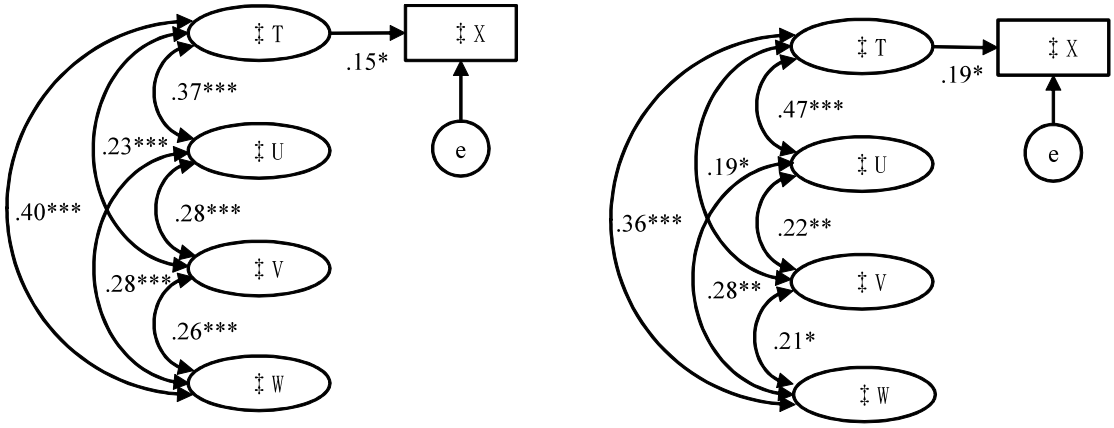
< Over 2,100 kg group >
(n = 427)

‡TInterest in public, ‡UDesire for fulfillment, ‡VDesire for household management, ‡WFrugal mind,
‡XIntention of CO2 emission reduction
* p<.001, ** p<.0001

Standard partial regression coefficient

Coefficient of correlation

Fig. 6 Path diagram of less than 1,900 and over 2,100 kg groups.



< 1,500 – 2,000 kg group >
(n = 213)

< 2,000 – 2,500 kg group >
(n = 141)

‡TInterest in public, ‡UDesire for fulfillment, ‡VDesire for household management, ‡WFrugal mind,
‡XIntention of CO2 emission reduction
* p<.005, ** p<.001, *** p<.0001

Standard partial regression coefficient

Coefficient of correlation

Fig. 7 Path diagram of 1,500-2,000 and 2,000-2,500 kg groups.

4. CONCLUSION

In this study, a new PCA system, FIT-PCA has been proposed which introduces the idea of feed-in tariff as an innovative energy and environment policy imposing economic burden on the citizens by their CO_2 emissions from their daily lives. Since the principle of the proposed FIT-PCA has "Simplicity", "Fairness" and "Effectiveness", it deals with the CO_2 emission only originated from fossil fuel energy consumption and it has a fixed price allowance trade instead of market trading unlike ordinary PCA systems. The CO_2 emission allowance is distributed to the citizens equally and the amount is determined based on the average CO_2 emission per person per year because it is expected that people who emit more CO_2 than the average may reduce their own emissions by recognizing how much they emit the CO_2 from the average.

In order to investigate the public acceptance and problems of the FIT-PCA, A questionnaire survey was conducted. As the result, the total support rate of FIT-PCA compared with assumed carbon tax was 60.5%. The detail discussion shows that they were interested in "fairness" of the policy and they felt that the difference of energy consumption by their residential areas was the most unfair factor. However, the result of correlation analysis between amount of CO_2 emission and residential conditions, it was found that the cold climate slightly affected only the consumption of heating oil.

About the effect by being aware of the average emission, it was found that the 2,000-2,500kg emission group has higher intention of CO_2 emission reduction from 1,500-2,000kg group. In order to reveal the cause of the difference, an exploratory factor analysis was tried and it was found that "interest in public" factor of these two groups was slightly different.

In the proposed FIT-PCA in this study, some important problems such as carbon leakage and difficulties of actual operation still remain. The authors will make small modifications of the rules to solve these problems and will try a social experiment in the future.

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