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A Study of Marketing Strategies for Electricity Pricing Plans Considering Willingness to Pay for Renewable Energy

Kirana Horie & Sun Jing

1. Department of Social Engineering, Nagoya Institute of Technology, Japan

Abstract: This research aims to create a power plan that takes into account consumer preferences in order to promote the spread of renewable energy. First, we built a mathematical model using a five-point questionnaire and conjoint cards. Next, we conducted a survey reflecting consumer attitudes and comparing them to existing power plans. Ultimately, we analyzed the obtained data using a mathematical model to clarify the amount of renewable energy that consumers accept and their needs.

Keywords: WTP (willingness to pay), renewable energy, transfer, electricity plan

INTRODUCTION

In Japan, due to the liberalization of electricity, ordinary households have been able to switch electric power companies since 2016[1], but consumers are reluctant to switch electric power companies, and it is difficult to say that knowledge about the need for renewable energy has spread [2]. Furthermore, the demand for renewable energy (hereinafter referred to as renewable energy) is increasing in society due to changes in temperature that can be felt in the sense of global warming, the spread of SDGs perspectives, and the instability of the world situation.[3][4]. To this end, the government introduced a tax that imposes a compulsory burden on consumers on consumers to purchase electricity produced by renewable energy in order to promote the spread of renewable energy. However, it is difficult to say that it has been accepted, and it is clear from some questionnaires that consumers are also reluctant to do so [5]-[7].

However, this trend cannot be ignored, and it is said that the amount of tax will inevitably increase in the future due to the spread of renewable energy towards 2030,[8] and it is difficult to ignore this trend. To this end, it is important to make efforts to increase consumer acceptance of renewable energy levies. It is also important to research the power plan for this purpose. In this study, we propose a mathematical regression model that combines multiple analysis methods and a mathematical model with reference to multiple analysis methods to investigate power plan switching. This aims to confirm the renewable energy plans that consumers will accept for the widespread adoption of renewable energy and to propose attractive power plans amid increasing competition among utilities [9]-[11]. In addition, based on numerical considerations, renewable energy (WTP, willingness to pay) We will also consider marketing strategies for attractive power plans that consider.

MATHEMATIC MODEL

In this study, we propose the following two mathematical models to examine the elements of renewable energy WTP and switching.

Hybrid Method

This model is a model for reflecting a 5-point questionnaire and a conjoint card questionnaire in a 1:1 ratio.

$$\widehat{y_k} = \alpha + \beta_o X_{ok} + \beta_l X_{lk} + \epsilon_k + \zeta_k \quad (1)$$

y is the WTP value, α is a constant term, o relates to data from the conjoint cards, β_o is the coefficient vector associated with the conjoint data, X_O is the matrix related to the data from the conjoint cards, l relates to data concerning the Likert scale, β_l is the coefficient vector concerning the Likert scale, X_l is the matrix related to the data concerning the Likert scale, ϵ_k is the error term within the data, and ,ζ_k is the error term associated with the data collection method.

$$y = \frac{1}{1 + e^{-(\alpha + \beta_o{}' X_{ok} + \beta_l{}' X_{lk} + \epsilon_k + \zeta_k)}} \quad (2)$$

Since the purpose of this study is to consider the transfer related to the WTP of renewable energy, we will consider a model to judge the transfer by adapting logistic analysis as shown in the above formula. y is the transferability, α' is the constant term, o is the data related to the conjoint card, ß-o.' is the coefficient vector related to the data of the conjoint, X_O. is the matrix related to the data related to the conjoint card, i is the data related to the Likert scale, and β_l' is the coefficient vector related to the Likert scale. X_l. is the matrix for data related to the Likert scale, ϵ_k is the error term within the data, and ζ_k is the error term according to the data collection method. Figure 1 shows an algorithm using an integrated mathematical model.

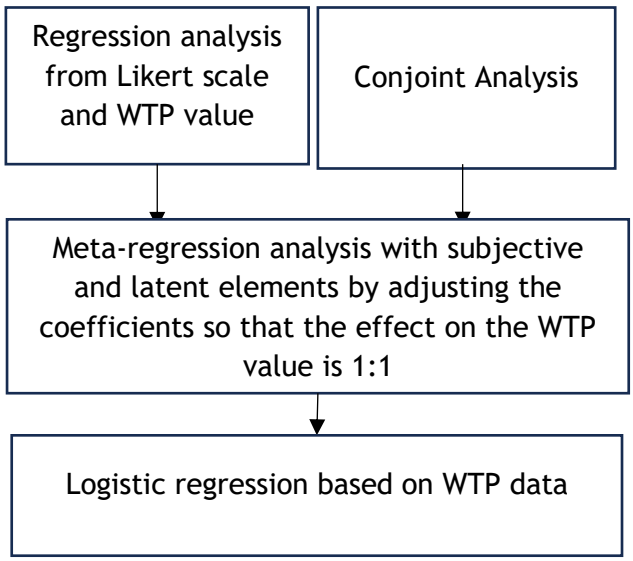

Figure 1: Hybrid Method Algorithm

Embedded Method

This model is a model in which the evaluation score of the conjoint analysis is adjusted by multiplication so that it varies to the same variation as a questionnaire on a five-point scale and is incorporated into the regression analysis of the five-point questionnaire.

$$\widehat{y_k} = \alpha + \beta_l X_{lk} + \gamma X_o + \varepsilon_k + c_k \tag{3}$$

l is the data related to the Likert scale, β_l is the coefficient vector related to the Likert scale, X_l is the matrix related to the data related to the Likert scale, γ is the coefficient to the data with the results of the conjoint analysis as a variable, and X_o is the data used as a membership function after summarizing the results of the conjoint analysis. ε_k is the error term by the membership function, and c_k is the error term by the linear regression equation.

$$y = \frac{1}{1 + e^{-(\alpha' + \beta'_l X_{lk} + \gamma' X_o + \varepsilon_k + c_k)}} \tag{4}$$

The model incorporating the results of the conjoint analysis as variables is adapted to the logistic analysis, and the formula for the transfer is as follows. l is the coefficient vector for the data related to the Likert scale, β_l' is the coefficient vector related to the Likert scale, X_l is the matrix for the data related to the Likert scale, γ' is the coefficient to the data with the results of the conjoint analysis as a variable, and X_o is the data used as a membership function after summarizing the results of the conjoint analysis. ε_k is the error term by the membership function, and c_k is the error term by the linear regression equation.

Figure 2 shows an algorithm using an embedded mathematical model.

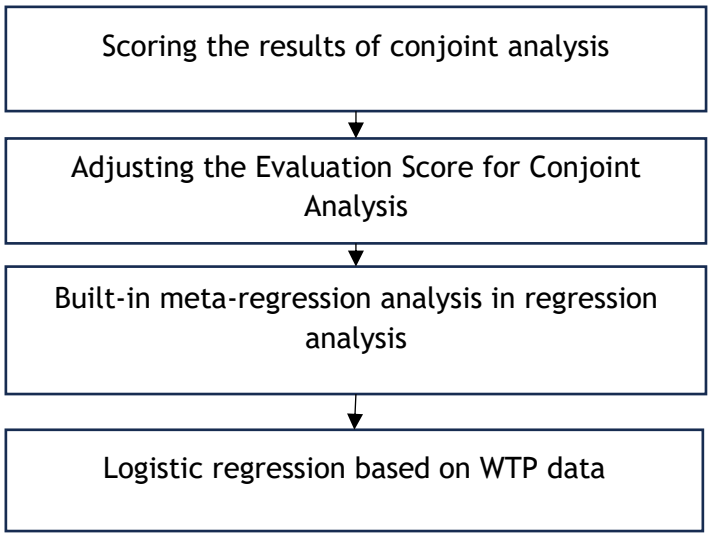

Figure 2: Embedded Method Algorithm

RESEARCH DESIGN

The three components of this study are the presentation material, a questionnaire on a five-point Likert scale, and a conjoint card.

Reference Materials

Several summary websites covering multiple actual electricity providers related to switching power companies were presented. The presented materials include information on switching incentives, estimated cost savings, and company details. In addition, among websites that provide such information, comparison-oriented sites that allow users to evaluate and compare options were presented as reference materials.

Questionnaire on a 5-point Likert scale

After considering several summary sites for switching power companies, we present them as materials for referring to several types of sites that are more detailed about switching power companies.

Conjoint Cards

L_{18} Create a questionnaire using the attribute levels of the table using an orthogonal table. It is shown in Table 1.There are 8 attributes applied to the direct table (transfer benefits, price, price breakdown, reviews, set plans, points, name recognition, renewable energy ratio), and only the transfer benefits have 2 levels, and the other attributes are 3.L_{18}

Table 1: Conjoint Cards

attribute	Level 1	Level 2	Level 3
Transit Awards	Model CB	Discounted	
price	cheap	Average	high
Price Breakdown	Basic fee: 0 yen	Average	Basic fee: 1000 yen
word of mouth	bad	ordinary	good
set	mobile phone	gas	without
point	Accumulates well	ordinary	I don't get it
popularity	famous	ordinary	New entrants
RE-E Ratio	low	ordinary	high

EVALUATION OF MATHEMATICAL MODELS

The usefulness of the model was determined using the t-test for renewable energy WTP.

$$t = \frac{\bar{x}_A - \bar{x}_B}{V\sqrt{\frac{1}{n_A} - \frac{1}{n_B}}} \tag{5}$$

$$V = \frac{\sum_{i=1}^{n_A} (x_i - \overline{x_A})^2 + \sum_{j=1}^{n_B} (x_j - \overline{x_B})^2}{(n_A - 1) + (n_B - 1)} \tag{6}$$

The model for switching power companies is based on the Hosmer and Lemeshow test, and the equation used for the Hosmer and Lemeshow test is as follows

$$\boldsymbol{\chi^2 = \sum_{i=1}^{k} \frac{(O_i - n_i \hat{\pi}_i)^2}{n_i \hat{\pi}_i (1 - \hat{\pi}_i)}} \tag{7}$$

From Table 2, both models exceeded the significance level of 0.05, which is appropriate.

Table 2: Evaluation of both models

	Integrated	**Built-in**
t-test (two-sided p-value)	0.43	0.82
Hosmer and Lemeshaw test	0.97	0.89

NUMERICAL RESULTS AND DISCUSSION

In this study, the subjects of the questionnaire were 55 students. Based on the questionnaire, we will consider the important factors for switching between renewable energy WTP and electric power companies, and the effect of presenting materials.

About Renewable Energy WTP

Figs. 3 and 4 show the results of each element of renewable energy WTP obtained from the integrated type and each element of renewable energy WTP obtained from the embedded type, respectively.

From Figure 3, it can be said that good reviews are positive and bad reviews are negative. Therefore, if the reputation is bad, no matter how much you try to do it, it may be in vain. It is considered that the most important thing is to properly manage the situation at the site or to use your voice for trouble handling and attitude. The result was that it could significantly increase WTP.

The fact that the basic fee is 0 yen, the high level of popularity, and the average word of mouth and there are no particularly bad points are not as good as the items

mentioned above, but they show a large positive value and can be said to be important. In addition, it can be said that the basic fee of 1000 yen, the WTP is low for things that are not well understood, such as new entrants, and things that are not well understood, such as new entrants.

From the above, it is considered necessary for effective marketing to seek a plan for the price structure situation related to word of mouth, popularity, and basic fees.

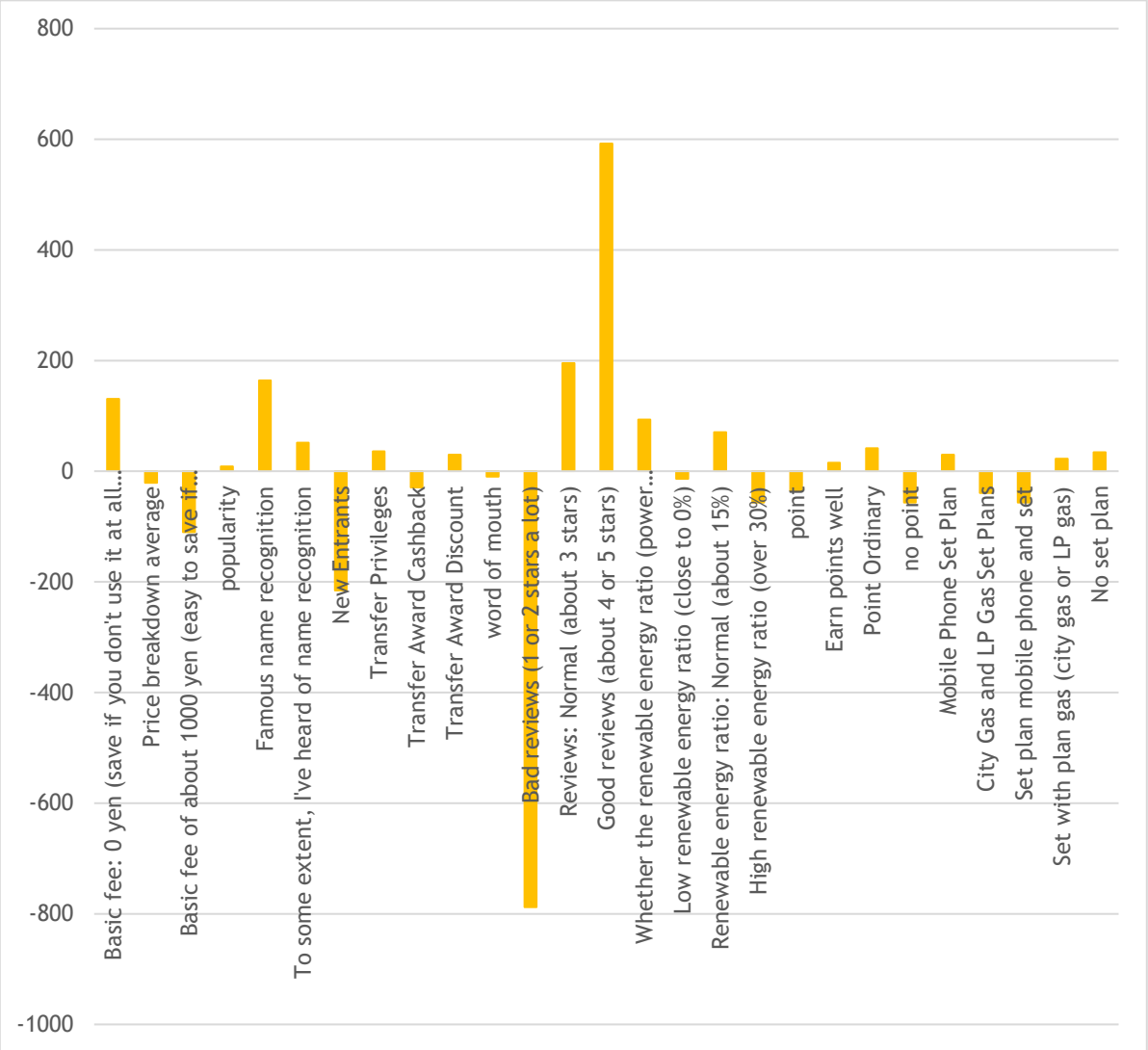

Figure 3: Elements of integrated renewable energy WTP

From the results of the embedded type from Fig. 4, the proportion of renewable energy ratio is higherThis can be confirmed by the fact that people who subjectively want to pay a high WTP have a high renewable energy ratio, that is, they strongly want to spread renewable energy. In addition, since many people think that the transfer benefit is important, it is considered important to approach the transfer benefit. In addition, Since the points show a large negative value, it was confirmed that there is not much need for points or that consumers are not very conscious of points.

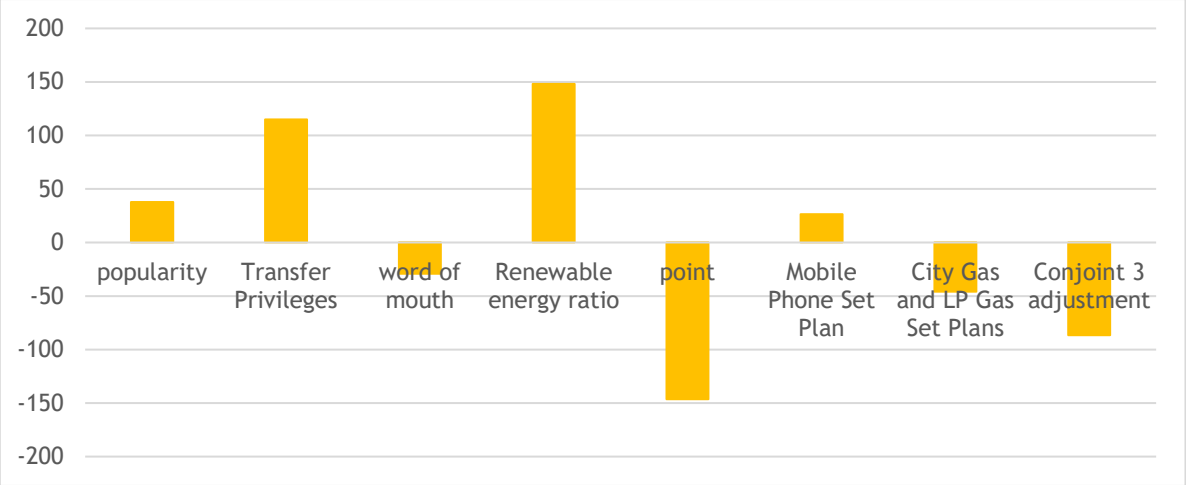

Figure 4: Elements of Embedded Renewable Energy WTP

From Figures 3 and 4, it can be said that in order to increase renewable energy WTP, it is necessary to promote renewable energy in a way that provides a single result while taking into account the renewable energy ratio, taking into account the sense of security, such as name recognition and word of mouth, and to focus on things that are returned to consumers in an easy-to-understand manner, such as transfer benefits.

About the Transfer Element of the Power Plan

Figures 5 and 6 show the results of each element of the power plan switch obtained from the integrated type and each element of the power plan transfer obtained from the embedded type, respectively. From Fig. 5, logistic regression analysis showed that the transfer benefit cashback type was positive and the discount type was negative.

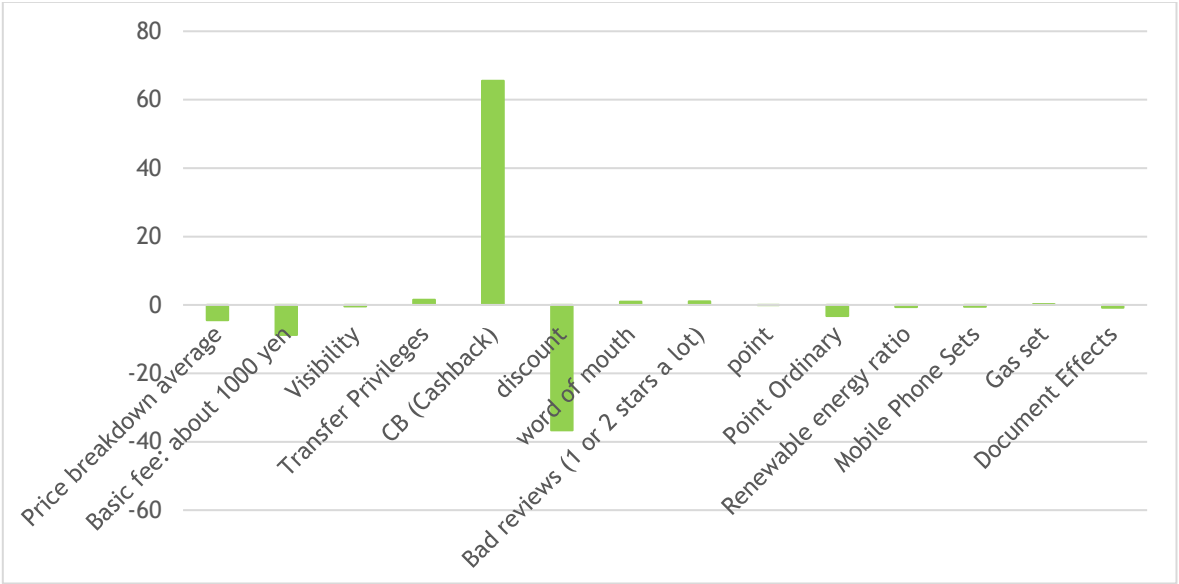

Figure 5: Integrated transfer element

Therefore, it is considered important to provide transfer benefits in the form of increasing consumers, especially cashback, in order to get them to switch to electric companies. In addition, from Fig. 6, it was confirmed that the transfer benefit is greatly affected by the transfer benefit, as in the case of WTP This indicates that the transfer is greatly influenced by the transfer benefits, and that more attractive benefits are emphasized in order to acquire new customers. Word of mouth shows positive values as well as the integrated WTP, indicating the importance of invisible parts such as attentiveness and thoughtfulness that can lead to reputation. In addition, in the case of the embedded type, the effect of presenting materials shows negative values.

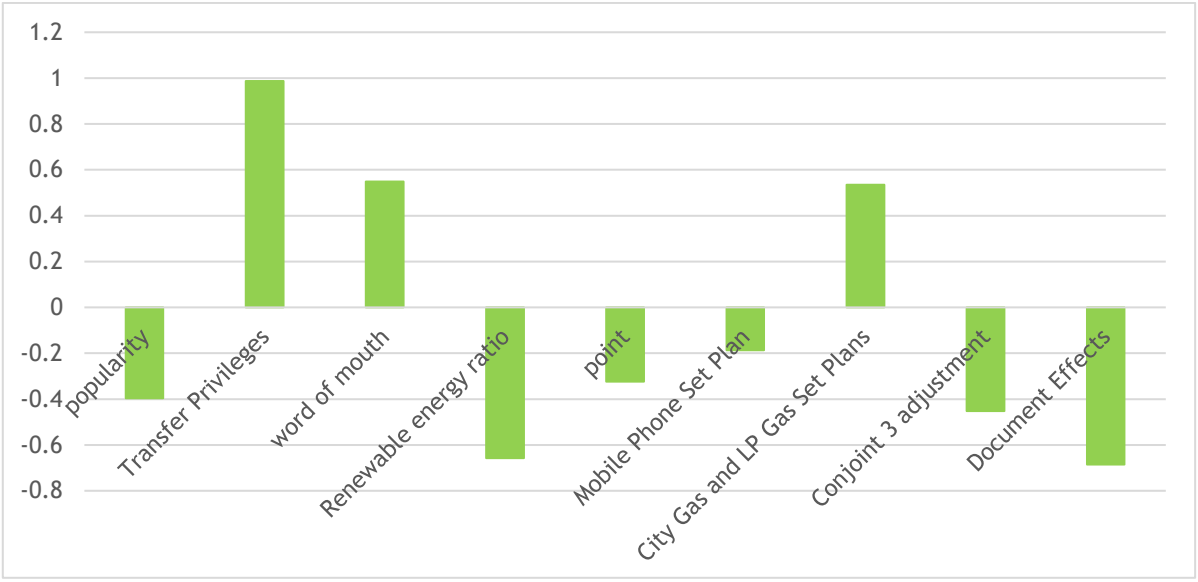

Figure 6: Built-in transfer element

From Figs. 5 and 6, it can be seen that the most important thing for the transfer plan is the transfer benefit. And from the results of the integrated graph, it is important that the content is a cashback type in the form of something to be received. Another important factor in the transfer that can be read from the graph is word of mouth. It can be said that it is important to respond in a pleasant way so that word-of-mouth improves, and in addition to that, it is important to have an attitude that does not disrespect consumers.

Effect of Presentation of Materials

Table 5 shows that the effect of data presentation is negative for both integrated and embedded models, and there is little effect.

Table 5: Effects of materials

	Integrated	Built-in
Document Effects	-0.79	-0.68

The reason why the impact was not seen was that the factors that the survey respondents originally thought about were more important subjectively and potentially than the content of the presented materials, and that the survey respondents may not have taken the time to look at the presented materials because they were not incorporated into the questionnaire and were asked for reference.

CONCLUSIONS

Based on the discussion of renewable energy WTP and the factors of switching to electric power companies, it can be considered that two factors are particularly important for attractive electricity plans: transfer benefits and word-of-mouth. In addition, since transfer benefits should be cashback type and word-of-mouth is seen more than imagined and used as a basis for judgment, it is important to sincerely face each customer in order to create an attractive electricity plan.

Using the model in this study, we were able to consider the amount of renewable energy accepted and the attractive electricity plan. In addition, it was confirmed that this model was in line with the actual data and was useful.

From the integrated model, it was possible to integrate the results of the survey results on the subjective Likert scale and the results of the conjoint analysis in line with the actual product selection to reflect the impact of each half with reference to the meta-regression model, and it was possible to analyze from two perspectives, subjective perspective and latent perspective. It is considered that we were able to present the analysis results of the WTP value.

As for the embedded type, we were able to analyze it in a simpler, more familiar, and simpler way than the integrated type by using the familiar question of the electric power company that wants to use the results of the conjoint analysis with reference to the concept of the meta-analysis model, and then incorporating it as a member-ship function. However, since the attributes and levels were specified in large quantities this time, it is difficult to say that each element could be analyzed and examined in detail.

In addition, it is necessary to think anew about the content and presentation method of the presentation materials.

The results of this study alone do not sufficiently estimate a large population, which is a characteristic of meta-analysis and meta-regression, so it is necessary to elaborate a model for estimating the population using a different approach.

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