How Does a Ride Point System Differ from Fare Reduction in Ridership of Public Transportation?

-An Empirical Analysis of the Mental Accounting Theory-

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Introduction

Excessive motorization has been causing the global and local environmental problems, such as global warming, depletion of fossil fuels and traffic congestion, and therefore modal shift policies from auto to mass transit are called for. Although TDM (Travel Demand Management) measures in addition to investing on transit infrastructures are implemented in Japan, significant modal shift has not been observed due to the following reasons. First, necessity of TDM is not fully understood by citizens. Second, the policy measures implemented in Japan are not attractive enough to make car users shift to transit. Third, the budget for TDM is very limited.

Under such circumstances, we have been proposing a TDM measure of transit ride point system (called 'travel eco-point') where one can acquire points when he/she uses an environmentally friendly transportation mode such as public transportation and can exchange the accumulated points to further incentives for environmentally friendly travel behavior such as transit tickets. This eco-point TDM measure is expected to promote public transportation usage without large budget because it stimulates the psychological aspect than monetary one. Thus, the travel eco-point system may provide psychological incentives as well as small economic one to affect travel behavior. In addition, the accumulated eco-points could visualize how much one has contributed to the environmental improvement and may help build attitude toward environmentally friendly behavior. The travel eco-point could also be served as the common value that unites other TDM measures such as road pricing and car sharing and also other environmentally friendly actions such as refusing plastic shopping bag. Social experiments on this system were carried out twice in Nagoya, Japan in 2004 and 2005 to collect behavioral data.

In this paper, we investigate the effect of travel eco-point system on shifting from auto to transit focusing on the difference in the effect of fare reduction. Traditional consumer choice models that assume the instrumental rationality cannot distinguish the effect of the eco-point and fare reduction We, however, observe that FFPs (Frequent Flyer Programs) and FSPs (Frequent Shopper Programs) proliferate as a very successful sales promotion. This paper demonstrates a methodology that reveals the differences among the effects of the measures based on empirical analysis.

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In this paper, a modeling framework is introduced first, then the empirical analysis is presented, followed by key findings and future works.

Theoretical Framework

Thaler (1985) proposed the mental accounting theory where the total utility is composed of the "acquisition utility" and the "transaction utility". The former is the net utility of purchasing and consuming the product. The latter is the psychological subjective utility that one may acquire in purchasing it. A positive transaction utility may generate when one believes the purchase is a good bargain. Total utility is the sum of the two types of utility:

$$U = AU(\overline{p}, -p) + \beta TU(-p : -p^*) \quad (1)$$

where

U: total utility,

AU: acquisition utility of purchasing the product of which value is $\overline{p}$ for price p

TU: transaction utility

β: unknown parameter how the individual prefers bargain or dislikes loss

The measure of transaction utility is the difference between the charged price(p) and the reference price(p*), which is based on the prospect theory (Kahneman and Tversky, 1984). Thaler (1985) states that the reference price represents the fairness of the price. The reference price was also defined by many researchers in marketing, e.g., the price of the most frequently purchased brand (Gabor and Granger, 1961), the price last paid or the buyer's notion of a fair price (Monroe, 1973) , and the average price (Diamond and Campbell, 1989). Variety of the definitions stems from the fact that the price of a consumer good fluctuates for sales promotion., The reference price of public transportation, however, can be considered as the fare actually charged because the fare rarely fluctuates.

The differences between a fare reduction measure and a ride point system are addressed using the above-mentioned mental accounting theory below.

Fare reduction measure case

Denote that p is fare prior to the implementation of a fare reduction measure and that $p\text{-}\Delta p$ is the reduced fare. We assume that any other attributes are not changed at the fare reduction.

One can assume that the transaction utility does not accrue unless the fare is changed. Therefore, the total utility before the implementation of the measure (U^{bf}) is:

$$U^{bf} = AU(\overline{p}, -p) \quad (2)$$

On the other hand, the total utility just after the implementation (U_d^{af1}) is:

$$U_d^{af1} = AU(\overline{p}, -(p-\Delta p)) + \beta_d TU_d(-(p-\Delta p) : -p^*) \quad (3)$$

Here, the reference price for public transportation (p^*) can be considered as the fare actually charged (p) because the fare is not frequently changed. Once the fare reduction is implemented, the

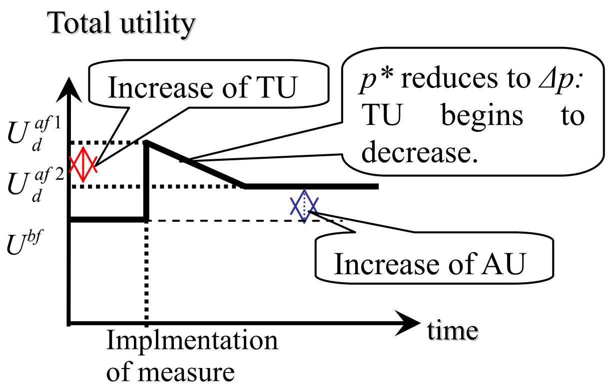

Figure 1: Time variation of the total utility for fare reduction

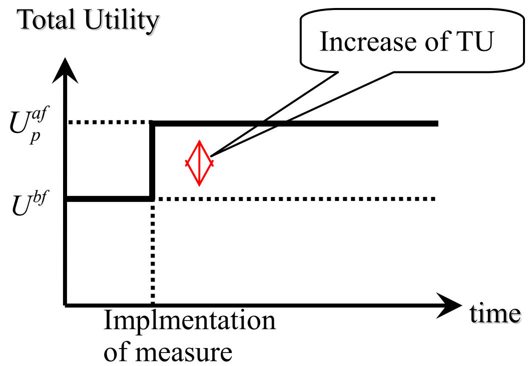

Figure 2: Time variation of the total utility for travel eco-point

transaction utility as well as the acquisition utility increases by the amount of Δp because the reference price is still p^* just after the implementation. However, it is fare to assume that the reference price gradually goes down to the fare after the implementation, i.e., p-Δp, as the marketing literatures mention. Then, the transaction utility reduces to zero and the total utility (U_d^{af2}) consists of only the acquisition utility:

$$U_d^{af2} = AU(\overline{p}, -(p-\Delta p)) \tag{4}$$

Figure 1 shows the variation of the total utility with time in the case of a fare reduction measure.

<u>Ride point measure (travel eco-point) case</u>

In the ride point system, or travel eco-point, a rider can obtain a refund by transit tickets by a reward rate of Δp per a fare amount of p.

The acquisition utility is may not change even after the implementation of the travel eco-point since the fare itself does not change. The transaction utility in this case is the utility of receiving Δp worth of reward, emcompassing expectation for reward received in the future, pleasure of receiving reward or accumulating points and so on. The total utility just after the implementation (U_p^{af}) is:

$$U_p^{af} = AU(\overline{p}, -p) + \beta_p TU_p(-(p-\Delta p) : -p^*) \tag{5}$$

The reference price in the case of the travel eco-point remains p^* because the fare to pay does not change. The positive transaction utility comes in at the implementation and the magnitude will not decrease even long after the introduction of the point system. Figure 2 shows time variation of the total utility in the case of travel eco-point measure.

Preliminary Result of Empirical Analysis

<u>Outline of the Data Used</u>

Data of a questionnaire survey conducted before the second social experiment of the travel eco-point are used in this study. The questionnaires were distributed to 3,000 households in Nagoya and 659 households (948 individuals) of them responded. The data used in this analysis are responses to questions of ranking seven measures for promotion of public transportation, including fare reduction, pre-paid cards with premium and the travel eco-point (Table 1). Another question asks them to choose one from six intention options to visit the city center by public transportation which are '1) I am already using public transportation, bicycle or walk in visiting the city center', '2) I will use', '3) I may use', '4) Not sure', '5) I may not use', '6) I won't use', if 'the most preferable measure', 'the fourth preferable measure' and 'the least preferable measure' will be implemented.

Rank logit model and ordered-responsed logit model are applied for the ranking and the intention of public transportation usage data, respectively. By excluding samples of current public transportation users, 144 individuals of current car users are finally used, and simultaneous estimation technique is adopted for model estimation.

Table 1: seven measure promoting transportation usage in the questionnaire

	Type of measure	Detail of measure
Measure 1	Fare reduction	5% reduction
Measure 2		10% reduction
Measure 3		20% reduction
Measure 4	Prepaid card with premium	300yen premium for 2,000yen
Measure 5		400yen premium for 2,000yen
Measure 6	Travel eco-point	500 yen prepaid card per 100 points
Measure 7		1,000 yen prepaid card per 100 points

Table 3: Estimation Result

Variables		Estimation(t-statistic)	
		Traditional model	TU model
Public transportation constant		4.56 (7.9)	1.49 (2.7)
Travel time		-0.217 (-0.4)	-0.449 (-0.8)
Travel cost (1,000 yen)		-11.5 (-9.4)	-3.02(-2.5)
Amount of fare reduction (1,000 yen)		-	44.1 (17.6)
Amount of premium for prepaid card (1,000 yen)		-	37.4 (7.8)
Amount of reward of travel eco-point(1,000 yen)		-	63.4 (5.9)
Dummy	Prepaid card (PC)	0.560(6.2)	0.081 (0.3)
	Eco-point(EP)	0.177 (2.2)	0.221(1.3)
	Driver's license (CL)	1.79(3.8)	1.01 (2.3)
	Car ownership (CO)	0.486 (2.1)	0.406 (1.8)
Threshold 1		3.59 (18.7)	3.79 (19.3)
Threshold 2		1.99 (15.7)	2.13 (16.1)
Threshold 3		0.712 (8.5)	0.753 (8.6)
AIC		2093.1	1907.9

Result

Table 2 represents the estimation result. The first column shows the estimation result of the traditional model, and the second one represents the result of the model in which the transaction utility is explicitly considered based on Thaler's mental accounting theory (TU model).

The AIC of TU model is significantly better than the traditional model, indicating that the model with explicit consideration of the transaction utility would better fit to our empirical data than the traditional model. The significantly positive coefficients of transaction utility, that is, the coefficient of amount of fare reduction (AOFR), amount of premium for prepaid card (AOPC) and amount of reward of eco-point (AOEP) also support the superiority of TU model, implying that individuals seem to feel some psychological pleasure for gains in addition to the conventional economic utility in the traditional models. With respect to the transaction utility, the coefficient of AOEP is the greatest, while AOPC's is the smallest. This means that people might feel the pleasure for gains in different way according to the type of policy measures, and especially reward from travel eco-point system would produce more pleasure than the others if the monetary value were the same. The coefficient of dummy variables for travel eco-point in TU model is also largest, suggesting that travel eco-point system seems to be the most cost-effective measure to promote public transportation usage. Comparing the parameter of travel cost to the ones representing the transaction utility, that is, AOFR, AOPC, and AOEP, the parameter estimates of transaction utility are 12 times (=37.4/|-3.02|) to 20 times (=63.4/|-3.02|) as higher as the one of travel cost. This result is quite different from the ones in marketing research. For example, Han et al. (2001) analyzed the effect of price discount for coffee using scanner panel data, and report that the transaction utility is 0.8 times to 3.5 times as higher as the price parameter. The reason for this discrepancy may be due to the fact that the data used in this study is the SP (stated preference) experiments in which only the cost aspects are varied. In such situation, respondents would tend to overreact to the changes in attribute even if those changes were trivial (e.g. Payne et al., 1993). Further empirical research related to the marginal rate of transaction utility and acquisition utility is strongly required in the field of travel behavior research.

The model performance is analyzed compared with the traditional model. Figure 3 depicts the variation of utility in change of reward or fare reduction rate, and the right hand side shows the result of TU model. Desirability of each measure in traditional model does not change over the entire area. On the other hand, preference of the fare reduction and prepaid card changes around 5% of fare reduction (reward) rate although the travel eco-point is the most preferable irrespective of the rate. Expecting that the point program might be generally preferred only if the reward rate were trivial while the desirability of fare reduction and prepaid card would rapidly increase as the amount of gains would grow, this result seems to be counterintuitive. This might occur since we assume the transaction utility to be expressed by a linear function. As the prospect theory by Kahneman et al. (1979) suggested, it seems better to apply non-linear functions to express the transaction utility since peoples attitude may vary according to the amount of gains or losses.

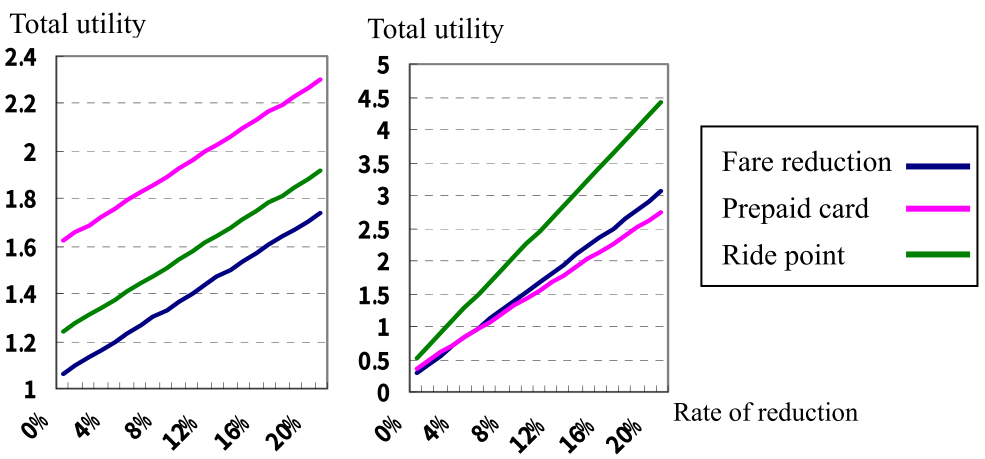

Figure 3: Utility differences for reduction (reward) rate among measures

Conclusion

In this paper, travel mode switching models based on the mental accounting theory were developed to evaluate the economic and psychological effects of TDM measures such as fare reduction, prepaid card with premium and travel eco-point. As a result of preliminary analysis, we provided several key findings:

- Including the transaction utility may significantly improve the goodness-of fit of conventional discrete choice models.
- The feeling of gain may differ among the measures especially in terms of transaction utility.
- Travel eco-point measure is the most preferable over any rate of reward and also cost-effective to promote public transportation usage compared to the fare reduction and prepaid card with premium.

We also find following issues of the proposed model.

- The parameters for transaction utility are much larger than the literature. Better results might be obtained if RP data were used.
- The result of model performance seems to be somewhat counterintuitive. Further elaboration is highly required with respect to the specification of transaction utility.

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