

more instable than those of RP models. The results suggest that the RP/SP models can mitigate the instability of SP models with the stability of RP data.

4.2 Carsharing Membership Choice

Membership choice was analyzed using logsum (LS) variables estimated with the modal choice models shown in Table 6. The model is estimated on the basis of the Partial Information Maximum Likelihood (PIML) approach. The application of the Full Information Maximum Likelihood (FIML) approach is one of further issues. The results are shown in Table 7. Carsharing membership fee is defined as the daily cost of being a carsharing member. The RP modal choice model was used for estimating the LS variable for non-members, whereas the RP/SP modal choice model was used for estimating the LS variable for CS members. Note that the data used for this estimation covers all respondents' choice of membership choice under the hypothetical cases. The results show that the model fitness is sufficiently high in all the four cities. Most of the coefficients of the explanatory variables are also statistically significant and consistent with their hypothesized effects on utility in the four cities. Additionally all coefficients of LS parameters are between 0 and 1, satisfying the theoretical requirement.

Table 7. Estimation results of carsharing (CS) membership choice model

Variable	Meidaimae		Hikarigaoka		Fujisawa		Utsunomiya	
	Coef.	t-stat.	Coef.	t-stat.	Coef.	t-stat.	Coef.	t-stat.
CS membership fee (Yen)	-0.16	-5.7**	-0.07	-4.9**	-0.06	-3.1**	-0.07	-4.0**
LS parameter: Non-CS member	0.08	8.0**	0.13	14.7**	0.09	9.8**	0.11	7.5**
LS parameter: CS member	0.01	0.7	0.07	7.4**	0.06	6.5**	0.07	4.7**
CS member dummy	2.79	1.3	-3.57	-2.2**	-9.75	-4.3**	-11.19	-4.8**
Number of observation	2904		3520		1984		3556	
Initial log-likelihood	-1432.74		-1790.40		-1016.85		-1773.76	
Final log-likelihood	-699.58		-701.22		-642.28		-813.37	
Adjusted likelihood ratio	0.51		0.61		0.36		0.54	

Note: ** indicates that the coefficient is significant at the 95 percent confidence level.

5. DISCUSSION

The implications of the survey and analysis results are summarized as follows: First, car owners are more aware of carsharing than non-owners; however, as compared to non-owners, fewer car owners have considered using carsharing services. This may mean that the individuals have difficulty rearranging their lives to be car-free once they own a car. On the other hand, carsharing may be attractive to non-owners because it provides opportunities to use a car. It could be suggested that carsharing may increase the overall usage of cars because non-owners may start using cars through carsharing services, and car owners may not change their transportation mode.

Second, 30-40 percent of the surveyed individuals said that they did not need to continue owning cars if they became members of carsharing services. Cevero and Tsai (2004) presents that the change in household motor vehicle ownership within the first two years of the San Francisco City CarShare Program, indicating that 29.1% of CS members reduce one or more cars while only 8.0 % of non-members reduce so. This may mean that the individuals in the four cities may more sensitively change their car-ownership once they become carsharing members than those in San Francisco.

Third, the individuals seemed to make rational decisions regarding their membership choices. Lower membership fees, cheaper carsharing-use charges, and better accessibility to

the nearest carsharing station were preferred. This supports the results shown by other studies in other countries such as the survey in San Francisco (Cevero, 2003) and the survey for university students in the United States (Zheng, et al., 2009). This suggests that a balanced combination of membership fees, time-charges, distance-charges, and accessibility is critical for enlisting more carsharing members even in the context of Japan.

Fourth, the comparative analysis of the four cities showed that the availability of carsharing services, public transportation service quality, trip distance, and household income all influence carsharing membership. Individuals have a better chance of becoming a member in an area where carsharing services are available. Individuals have less motivation to use carsharing in areas where cars are the dominant transportation mode owing to poor public transportation. The market potential of carsharing may be weaker in areas with high average trip distances. Individuals in low-income areas may not consider carsharing to be economically viable. These results suggest that the potential carsharing markets may be located in urban areas where middle- to high-income people reside and where high-quality public transportation is available. This may be regarded as the neighborhood residential model typically found at the early stage in North America (Shaheen, et al., 2009). This probably reflects the fact that the carsharing market in Japan is still at the primitive stage and its diversification has not yet started much.

Finally, although the modal choice models in Fujisawa and Utsunomiya did not have sufficient goodness of fit, the modal choice and carsharing-membership-choice models were successfully estimated. They could be useful for analyzing the potential demand of carsharing.

6. CONCLUSIONS

This paper reported the results of a questionnaire survey of carsharing in four Japanese cities. Initially, the awareness, expected actions regarding car ownership, stated choice of carsharing membership, and modal choice were analyzed using the collected data. Subsequently, the modal and carsharing membership choices were analyzed. These results give lessons to carsharing operators. For example, the results showed that the ten-minute walk to the nearest station discourage individuals from becoming members. This may suggest that the CS stations should be located at the places within ten-minute-walk distance from residential areas. The results also showed that the awareness of carsharing highly depends on the car ownership. This may suggest that the carsharing operators should have the different marketing strategies to car owners from those to non-owners. Next, the results also suggest important findings to the transportation planners. For example, the results indicated that carsharing may increase the overall usage of cars because non-owners may start using cars through carsharing services while car owners may not change their transportation mode. Furthermore, the estimated demand models also contribute to the estimation of the potential impacts of carsharing introduction on the local transportation market in the four cities. Particularly the results may suggest that the combination of SP and RP data leads to the stable estimation of the demand forecast models. This could be useful for local transportation planner to predict the future travel demands including carsharing.

It should be noted, however, the survey data have limitations. For example, like other stated preference surveys, this study is subject to an optimism bias, indicating over 20 % of respondents reported that they will join the CS member under the specific conditions in the three cities. It may be also affected by the selection bias because, in our survey, some data were collected through the face-to-face interviews while other data were collected through the

self-completion report. More research is required to overcome these limitations including the in-depth interview surveys and focus group meeting.

Several issues that must be addressed in further research are as follows: First, the dataset do not contain any carsharing users in the four cities. This simply reflects the results of the random sampling in the target areas. As the data of carsharing users should be useful for understanding the potential carsharing use, the additional surveys covering carsharing users are required to strengthen the results of this survey. Second, the modal choice models in Fujisawa and Utsunomiya must be explored further. A model with a non-linear utility function may be tried for better estimation results. Third, the demand models for carsharing should be verified with the observed dataset of modal choice of existing carsharing users. One of the difficulties of this analysis was collecting data on existing carsharing users. In fact, no current carsharing user responded to our household surveys. The customer information of carsharing services is usually collected by private carsharing operators and is not available to the public. Thus, it may be necessary to conduct joint research with these private operators to verify the data.

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