Evaluation of Community Café's Utility for Public Transportation Use in a Local Community in Japan

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Abstract: This study discusses the usefulness of a community café as a bus waiting place in local community, depopulated area in Japan. The idea is that passengers can wait comfortably for a bus at a community café even when financial constraints have caused the waiting time to increase as a result of reductions in transportation service frequency. To analyze the relationship between passenger's satisfaction with bus transportation when a community café is used as a bus waiting place, a multiattribute utility function (MUF) and orthogonal arrays were used. The analysis shows that the utility function scores for factor combinations such as community café as a bus waiting place and either longer waiting time, or higher bus fare are higher than those for the combinations of canopied shelter with seats and either shorter waiting time or lower bus fare.

Keywords: Public Transportation, Community Café, Level of Service

1. INTRODUCTION

Recently in many local communities in Japan, public transport ridership has been decreasing because of demographic aging and depopulation. Local governments are struggling to maintain public transportation services at a comfortable level for users. They are facing the dilemma of needing to maintain public transportation for residents' mobility while reducing public transport costs.

A number of communities have introduced Demand-Responsive Transport (DRT) services such as on-demand bus services. However, because of low transport service demand, the bus transport service frequency is also low in those communities. Therefore, bus users, most of whom are elderly, have to wait for a long time after they finish shopping or go to a hospital downtown. The best way to reduce passenger waiting time is to increase bus service frequency; however, this is not cost efficient because of the small ridership.

The improvement and revitalization of the town center is also an important issue for local communities. The establishment of community café has been attracting attention recently in Japan as a measure for town center revitalization. The main purpose in establishing a community café is to offer the public a space not just for eating and drinking, but also for deeper personal interactions. Community cafés are usually managed by non-profit organizations.

This study examines the potential of a community café to function as a bus waiting place that maintains user satisfaction with bus transport while also realizing cost-efficient public transportation. To analyze the relationship between passenger satisfaction with bus

transport services and the use of a community café as a bus waiting place, a multiattribute utility function (MUF) was applied by using orthogonal arrays. A questionnaire survey to collect data was conducted in Atsuma Town (pop. 5,000), in Hokkaido (Figure 1).

Studies on bus waiting time have focused on the operational state of bus transport toward reducing or estimating waiting time. However, few studies have evaluated passenger waiting time with regard to local transport service levels in local communities. Furthermore, a community café as a waiting place for public transport has not been included in factors for evaluation of public transportation service levels. This study focuses on the potential of a community café as a bus waiting place to make up for reduced levels of bus transport services, through a comparison with a conventional bus stop or a bus stop shelter.

Figure 1. Location of Atsuma town, JAPAN

2. COMMUNITY CAFÉS IN JAPAN

In recent years, community cafés have become more numerous throughout Japan, and these cafés have gained attention as a measure to revitalize downtowns. A community café is more than just a coffee shop. It is also a space for deepening personal interactions. In many communities, vacant shops in the central area have been converted into community cafés. A community café is used for various events, including group activities, concerts and exhibitions organized by community members (Figure 2). Community cafés are distinguished by their openness to the public and their management by a community-oriented non-profit organization. In addition to these, this study investigates the potential of a community café as a bus waiting place with respect to making up for reductions in bus transport service levels, through a comparison with a conventional bus stop or bus stop shelter.

Figure 2. Activities held at a community café in Japan

3. APPLICATION OF MULTIATTRIBUTE UTILITY FUNCTION USING ORTHOGONAL ARRAYS

3.1 Application of Multiattribute Utility Function

This study uses a multiattribute utility function (MUF) and orthogonal arrays to quantitatively analyze resident satisfaction with bus transport service regarding community café's function as a bus waiting place. Utility functions usually include a number of attributes, so they are applied as multiattribute utility functions. It is quite difficult to derive a general function because of non-dissociating interactions among attributes. Therefore, a verification of the independence of mutual attributes is required in order to construct multiattribute utility functions. This study uses a multiattribute utility function and orthogonal arrays to address those problems.

Using MUF with orthogonal arrays alternates the process of the test of independence among attributes to determine the type of utility function with an orthogonal Table that is experimentally designed. The functions derived through MUF and orthogonal arrays follow:

Single-attribute utility function

$$U_i(x_i) = \left| \left(x^* - x_{iW}\right) \Big/ \left(x_{iB} - x_{iW}\right) \right|^{r_i} \quad (1)$$

Multilinear utility function

$$U = \sum_{i=1}^{n} k_i U_i(x_i) + \sum_{i=1}^{n} \sum_{j>i} k_{ij} U_i(x_i) U_j(x_j) + \sum_{i=1}^{n} \sum_{j>i} \sum_{l>j} K_{ijl} U_i(x_i) U_j(x_j) U_l(x_l) + \cdots + k_{12\cdots n} U_1(x_1) U_2(x_2) \cdots U_n(x_n) \quad (2)$$

Multiplicative utility function

$$U = \sum_{i=1}^{n} k_i U_i(x_i) + K \sum_{i=1}^{n} \sum_{j>i} k_i k_j U_i(x_i) U_j(x_j) + K^2 \sum_{i=1}^{n} \sum_{j>i} \sum_{l>j} k_i k_j k_l U_i(x_i) U_j(x_j) U_l(x_l) + \cdots + K^{n-1} k_1 k_2 \cdots k_n U_1(x_1) U_2(x_2) \cdots U_n(x_n) \quad (3)$$

Additive utility function

$$U = \sum_{i=1}^{n} k_i U_i\left(x_i\right) \quad (4)$$

where,

x_{iW}: lowest level for each attribute
x_{iB}: highest level for each attribute
r_i: degree of risk preference
k_i: scaling coefficient

The use of orthogonal arrays enables evaluation factors (attributes) to be assigned interactively. In turn, this makes it possible to test the effects of attribute interactions by analysis of variance (ANOVA). In the above equations, k_i is a scaling coefficient that reflects the degree of importance of each evaluation factor.

MUF can analyze bus users' satisfaction of service level from several factors and also analyze which factor is important for users.

3.2 Definitions of Evaluation Factors and Their Ranks by User Satisfaction with Bus Transport Services

This study aims to evaluate the usefulness of a community café in the central area of Atsuma Town as a bus waiting place with regard to user satisfaction with bus transport services. For the analysis, evaluation factors including waiting time, bus fare, walking distance (from the last place visited before the bus waiting place on the way back home) and type of bus waiting place were selected. Table 1 organizes these evaluation factors and assigns three levels of bus user satisfaction: high, moderate and low.

Table 1. Evaluation factors and imagined user satisfaction

	High satisfaction	Moderate satisfaction	Low satisfaction
Waiting time	30 minutes	1 hour	2 hours
Bus fare (one way)	100 JPY (1.3 USD)	200 JPY (2.6 USD)	300 JPY (3.9 USD)
Walking distance	30 m	300 m	500 m
Type of waiting place	Community café	Canopied bus shelter w/ seats	Uncanopied bus stop w/o seats

The types of waiting places include a community café where bus users can enjoy conversations with friends and events while waiting, a canopied bus shelter with seats, and an uncanopied outdoor bus stop without seats.

Community café Canopied bus shelter w/ seats Uncanopied bus stop w/o seats

Figure 3. Type of waiting place in the questionnaire

The evaluation factors that fall in the highest level and lowest level of imagined satisfaction were assigned to L8 orthogonal arrays, and on the basis of the resulting 8 conditions produced by the given factor combinations, bus users were surveyed by questionnaire. Figure 4 is the image of questionnaire, one of eight factor combinations. The respondents reported their satisfaction for eight factor combinations according to five levels: very satisfied, satisfied, neither satisfied nor dissatisfied, not satisfied and very unsatisfied. This study assigned the scores of 100, 75, 50, 25 and 0 to each of the above satisfaction levels, respectively. These evaluations were used to identify the scaling coefficient for the utility functions.

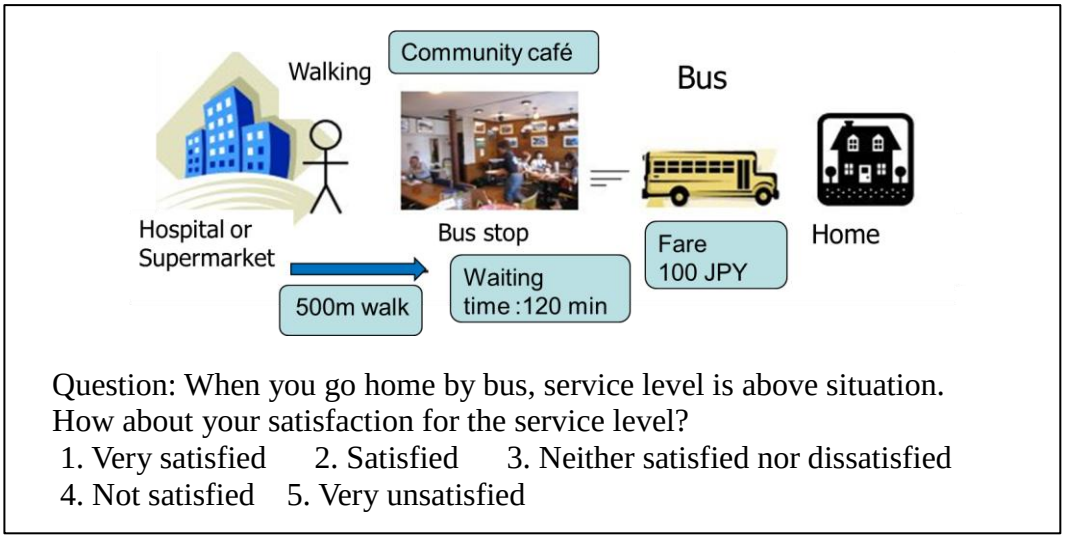

Figure 4. Image of questionnaire

As for moderate satisfaction level of evaluation factors, the respondents reported their satisfaction for each factor respectively, according to five levels: very satisfied, satisfied, neither satisfied nor dissatisfied, not satisfied and very unsatisfied. These evaluations were used to identify the degree of risk preference for the utility functions.

4. QUESTIONNAIRE SURVEY IN ATSUMA TOWN

4.1 Outline of the Survey

A questionnaire survey was conducted in Atsuma Town, Hokkaido, Japan in December 2009. The questionnaires were distributed by manual posting at each household and were collected by mail. Two copies of the questionnaire were distributed per household, with 1242 copies of the questionnaire delivered to 621 families, and 296 copies collected from 180 families for a collection rate of 28.9% for families and 23.8% for questionnaires. Because the elderly are dominant among bus transport users and the elderly at households do not tend to fill out the questionnaire sheets, to increase elderly samples in the survey, the questionnaire was conducted also by interview with the elderly at a club that is used as a place for activities by the elderly. The elderly who answered the questionnaire by interview were distinct from

those who responded to the questionnaires delivered to households. The questionnaire conducted by interview was done with the interviewer asking the elderly interviewee each of the questions in the questionnaire and marking the responses on the questionnaire sheets on behalf of the respondent. 54 questionnaires were collected by interview, for a total of 350 questionnaires.

4.2 Respondent Attributes and Transportation Modes

Males and females accounted for 48% and 52% of respondents, respectively. Respondents aged 60 or older accounted for 59% of respondents (Figure 5). The transportation mode reported to be most frequently used is private car, accounting for more than 70% of respondents (Figure 6). 77% of the bus users are aged 60 or older. This suggests that elderly people are the predominant bus users. This study focuses on elderly people as main bus users, which is not a bias. When interviewers asked elderly people, it was found that almost of all elderly interviewee understood the level of bus services, including locations of bus stops.

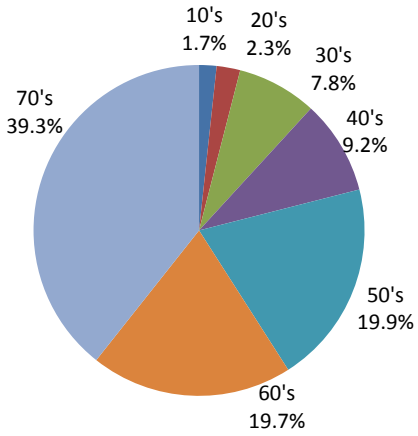

Figure 5. Demographic breakdown of respondents

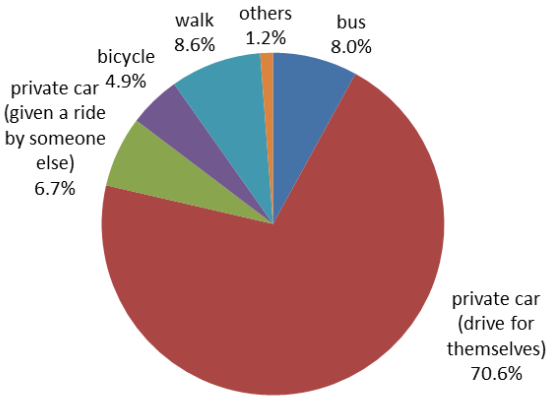

Figure 6. Most frequently used transportation mode

5. CONSTRUCTION OF A MULTIATTRIBUTE UTILITY FUNCTION USING ORTHOGONAL ARRAYS

5.1Analysis of Variance (ANOVA)

To construct utility functions that show bus user satisfaction with bus transport services, the effectiveness of the evaluation factors in raising the satisfaction with bus services was analyzed by ANOVA. Scores given by respondents for every combination of evaluation factors were subjected to ANOVA. Table 2 shows the result of ANOVA for questionnaire respondents. Only the type of waiting place shows an effectiveness whose significance level is at least 5%, so ANOVA was analyzed again by focusing on the respondents age 60 or older (Table 3). In

Table 2. Analysis of variance (All respondents)

Factor	Variation(S)	Degree of Freedom(f)	Variance(V)	Variance ratio(F_0)	Contributing ratio (R)

A (Type of waiting place)	0.30	1	0.30	13.71*	49.03
B (Waiting time)	0.11	1	0.11	4.92	17.61
C (Bus fare)	0.11	1	0.11	4.92	17.59
D (Walking distance)	0.05	1	0.05	2.22	7.93
A*B	0.00	1	0.00	0.05	0.18
B*C	0.02	1	0.02	1.14	4.10
E (Error)	0.02	1	0.02		3.58

*effectiveness whose significance level is at least 5%

Table 3. Analysis of variance (Respondents aged 60 or older)

Factor	Variation(S)	Degree of Freedom(f)	Variance(V)	Variance ratio(F_0)	Contributing ratio (R)
A (Type of waiting place)	0.32	1	0.32	28.55*	52.75
B (Waiting time)	0.09	1	0.09	8.14*	15.04
C (Bus fare)	0.12	1	0.12	11.02*	20.35
D (Walking distance)	0.04	1	0.04	3.41	6.30
A*B	0.00	1	0.00	0.01	0.02
B*C	0.02	1	0.02	2.00	3.69
E (Error)	0.01	1	0.01		1.85

*effectiveness whose significance level is at least 5%

this case, three factors represent the effectiveness and this study conducted MUF by using orthogonal arrays targeting elderly people (aged 60 or older). Main bus users are elderly, therefore this study assumed that evaluation by elderly was almost the same with the evaluation by all public transport users.

Because the results of ANOVA show that the interactions among evaluation factors do not represent significant level of effectiveness, that is, evaluation factors are independent, additional utility functions are applied.

5.2 Multiattribute Utility Function Using Orthogonal Arrays

Parameters of utility functions are as shown in Table 4 and the utility functions are derived by using Equation (5). Degree of risk preference is calculated by normalization of evaluation scores of moderate level of each factor. Scaling coefficient is the weight of contributing ratio among factors that represent the effectiveness by ANOVA.

Table 4. Parameters of utility functions

Factor	Degree of risk preference	Scaling coefficient
A (Type of bus waiting place)	0.781	0.598
B (Waiting time)	2.182	0.171
C (Bus fare)	0.839	0.231

$$U = 0.598\left(\frac{x_1}{1.0}\right)^{0.781} + 0.171\left(\frac{x_2}{1.0}\right)^{2.182} + 0.231\left(\frac{x_3}{1.0}\right)^{0.839}$$

(5)

In equation (5), x_1, x_2 and x_3 are converted from the values of evaluation factors. For example, 30 minutes of waiting time is convert to 1 (highest), 120 minutes is convert to 0 (lowest).

Figure 7 shows the changes of utility scores by waiting time that are obtained by Equation (5). In this case, the three types of bus waiting place are evaluated with the bus fare fixed at 200 JPY. Figure 8 shows the changes of utility scores by bus fare. In this case, the waiting time is fixed at 1 hour and the three types of bus waiting place are evaluated.

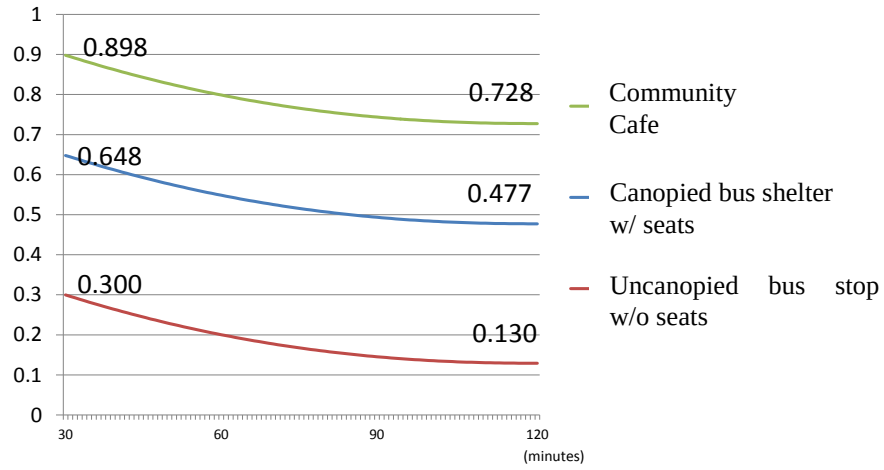

Figure 7. Changes in utility scores by waiting time (Bus fare of 200 JPY)

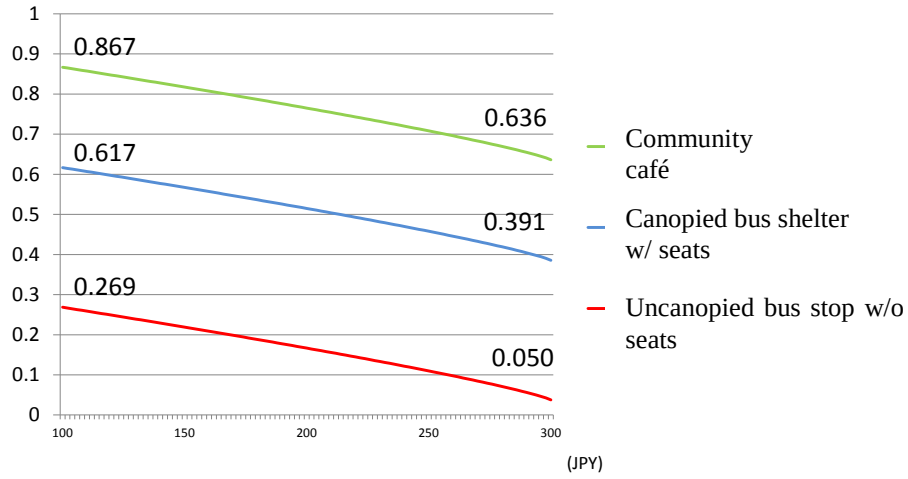

Figure 8. Changes in utility scores by bus fare (Waiting time is 1 hour)

Figure 7 shows that the utility score when the waiting time is 2 hours and the bus waiting place is a community café is higher than the score when the waiting time is 30 minutes and the bus waiting place is a canopied bus shelter with seats. Figure 8 shows that the utility score when the bus fare is 300 JPY and the bus waiting place is a community café is higher than when the bus fare is 100 JPY and the bus waiting place is an uncanopied bus stop without seats.

It is clarified that a community café may make up for a low level of bus transport services in a local city.

Actually community café as bus waiting place is much more attractive than other options(canopied bus shelter with seats and uncanopied bus stop without seats). But it is not important to compare only among bus waiting place options. This study makes importance to compare the combinations including other factors(waiting time and bus fare). From Table 3, 3 factors are effective and contributing ratio of "error" is small, so this study concludes there is no bias for respondents' evaluation.

6. EVALUATIONS OF BUS TRANSPORT SERVICES IN ATSUMA TOWN

6.1 Evaluation of Existing Bus Transport Services

Atsuma Town has five bus routes (Figure 9), with three departures per day for each route. Passengers can use two bus transport services per route to go to the central area of Atsuma and to make a return trip from the central area. This study focuses the return trip from the central area and evaluates that state of bus service operation in Atsuma by using Equation (5). For waiting time, the time interval between the first and second bus (1), and that between the second and third bus (2) are applied.

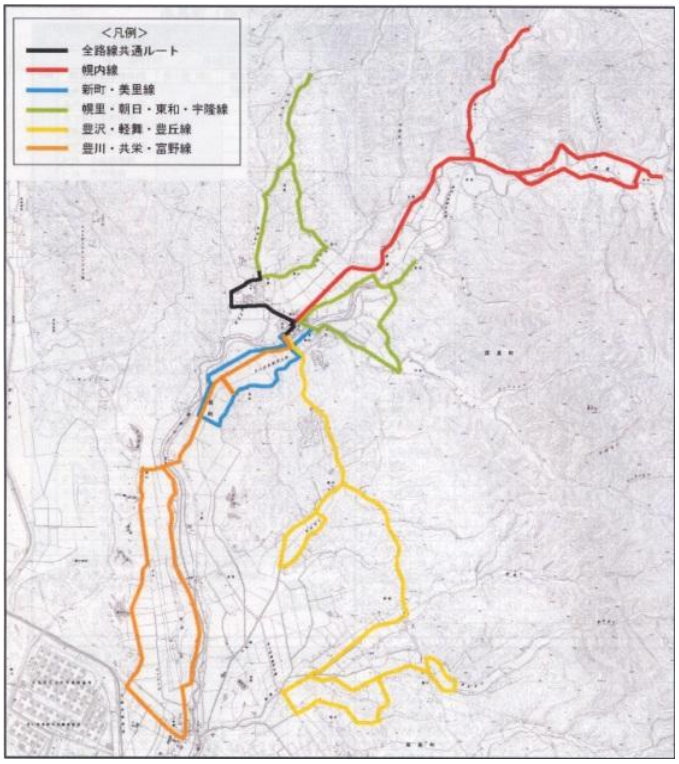

Figure 9. Bus routes in Atsuma town

Table 5 shows the utility scores of each bus routes in 2011. The type of bus waiting place here is canopied bus shelter with seats. Bus fare for the elderly is 100 JPY. And waiting time is analyzed from the bus timetable.

Table 5. Utility score of bus services of Atsuma town under the situation in 2011

Route	Waiting place	Fare	Waiting time	Utility Score

Route A	Canopied bus shelter with seats	100 JPY	Interval (1)	48 min	0.684
			Interval (2)	120 min	0.579
Route B			Interval (1)	90 min	0.594
			Interval (2)	81 min	0.607
Route C			Interval (1)	105 min	0.582
			Interval (2)	65 min	0.637
Route D			Interval (1)	59 min	0.653
			Interval (2)	120 min	0.579
Route E			Interval (1)	113 min	0.580
			Interval (2)	85 min	0.600

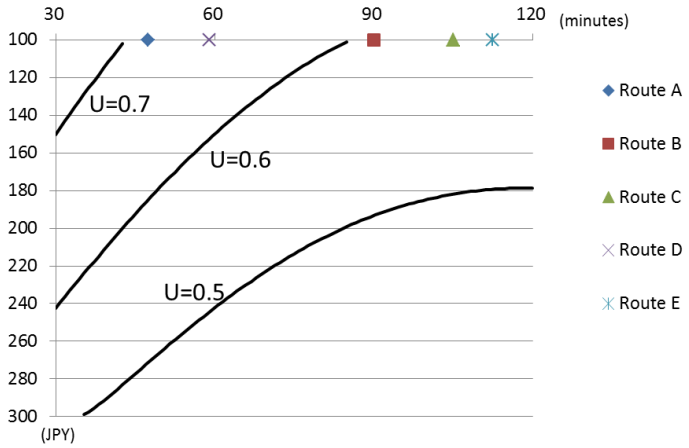

Figure 10. Utility scores of bus transport services (bus service interval (1))

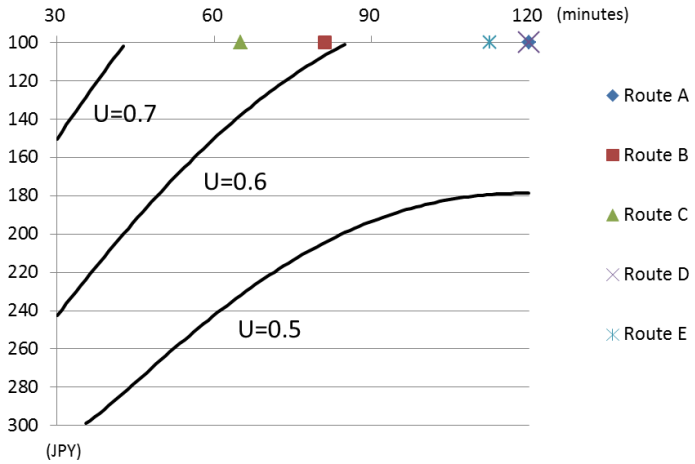

Figure 11. Utility scores of bus transport services (bus service interval (2))

In Figure 10 and 11, the vertical axes show bus fares and the horizontal axes show waiting time. Under the situation in 2011, the utility scores exceed 0.6 for only four bus services.

By using these figures, the position of evaluation of bus service is clear from the viewpoint of bus fare and waiting time. We can also understand how much can fare be raised

within same utility score.

6.2 Evaluation of the Case When the Bus Waiting Place Is a Community Café

If the bus waiting place is replaced to a community café, bus passengers' satisfaction may improve. This study analyzed the utility scores for the case in which the bus waiting place is a community café (Table 6).

From Table 6, and Figures 12 and 13, the analysis results indicate that the utility scores exceed 0.8 for all bus transport services. In other words, a community café can contribute directly to increases in passenger satisfaction with bus transport services without increasing the bus service frequency.

Table 6. Utility score of bus services in the case of community café

Route	Waiting time		Utility Score	
			Canopied bus shelter w/ seats	Community café
Route A	Interval (1)	48 min	0.684	0.934
	Interval (2)	120 min	0.579	0.829
Route B	Interval (1)	90 min	0.594	0.845
	Interval (2)	81 min	0.607	0.857
Route C	Interval (1)	105 min	0.582	0.833
	Interval (2)	65 min	0.637	0.887
Route D	Interval (1)	59 min	0.653	0.903
	Interval (2)	120 min	0.579	0.829
Route E	Interval (1)	113 min	0.580	0.830
	Interval (2)	85 min	0.600	0.850

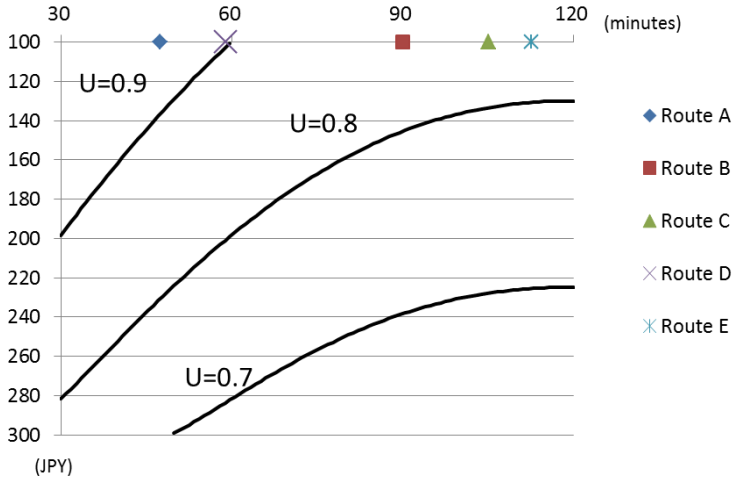

Figure 12. Utility score for a community café (bus service interval (1))

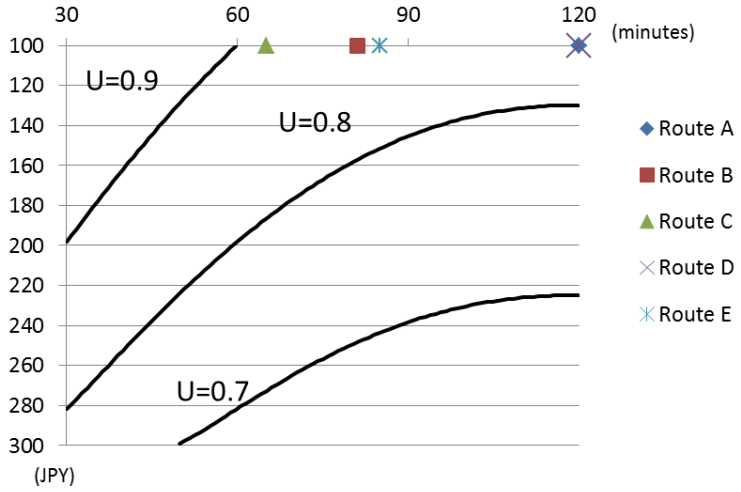

Figure 13. Utility score for a community café (bus service interval (2))

7. CONCLUSIONS

This study clarified that a community café can make up for a low level of bus service in a local community. A number of local municipalities in Japan have been trying to introduce DRT to reduce the operational costs of public transport, given that improving bus transport services is difficult because of budgetary constraints. This study proposes to utilize a community café as a bus waiting place to maintain public transport use without increasing bus service frequency. This idea could be applied to public transport planning.

Not only will bus passengers use a community café but so will private car users, which means that such cafés have the potential to serve as places to foster relationships between community members and, thus, that community cafés could become centers for local revitalization. They are also expected to be an incentive to increase the opportunities for the elderly to go out. And that has a possibility of the promotion of using bus service by the elderly.

Community café has attracted attention in the field of town development. However it is necessary to combine public transportation planning with town development activity especially in local community of rural area.

This study clarified the utility of community café based on the questionnaire survey. As a future issue, this study will continue to evaluate a community café by demonstration experiment held in Atsuma town.

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