Car Passenger Transport and Barriers to Community Bus Use in a Mountainous Underpopulated Region in Japan

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Abstract: Bus service supply has diminished and finally abolished in an underpopulated region where public transport demand is in an extremely low density. Its mobility is very low as well as restrictive for elderly people and disadvantaged people who have no private means. The paper analyzes travel behavior by car passengers and community buses in a mountainous underpopulated region, Yamakoshi in the city of Nagaoka, Niigata in Japan and estimates travel mode choice models using travel diary data to reveal the constraint factors of mobility for elderly people. Finally, the paper clarifies an important factor of 'walking distance from home to a bus stop' to shift travel mode from car passengers into an exclusive club bus system for elderly people.

1. INTRODUCTION

Birthrate decline and a growing proportion of elderly people become a serious problem in local cities in Japan, in particular very serious in a mountainous and underpopulated region. Since Ministry of Land, Infrastructure, Transport and Tourism (MLIT) deregulated bus service industry in supply & demand adjustment all over Japan in 2002, bus service supply has diminished and finally abolished in an under-populated region where public transport demand is in an extreme low density. Its mobility is very low as well as restrictive for elderly people and disadvantaged people who have no private means such as cars. Their decline of mobility presents the issues of social exclusion particularly in Britain (Karen, 2006). Their mobility is usually supported by the modes of "car passengers" and community buses. "Car

passengers" mean a travel mode sitting as a car passenger in a private car driven by his/her family members or friends.

Konno et al. (1994) investigated the actual situation of car passenger transport and suggested its important role for elderly people. In an underpopulated and mountainous region school bus is often operated by the municipality. Nitta and Do (1997) forecasted modal shift to bus for elderly people. Recently Fügenschuh (2009) solved bus scheduling problem presenting a possibility to make school bus scheduling effective by shifting the beginning time of schools. There are several researches which pointed out specific issues for study. Handy and Niemeier (1997) indicated that it is difficult to understand the needs of latent activity based on the analysis of actual behavior data under the low level of service in an underpopulated region. Tanimoto and Kita (2001) criticized the method of transport planning which focuses only on activity needs in a local city.

There have been many researches on mobility for an underpopulated region supplied by low level service of public transport. However, there exist few researches which analyze travel activities using travel diary data for plural days including short trips in a rural region, even though there are many such kinds of researches for urban regions. So that we conducted a travel diary survey of a week in a typical mountainous under-populated region, Yamakoshi in the city of Nagaoka, Niigata in Japan. The paper analyzes travel behavior by car passengers and community buses in a mountainous and underpopulated region, Yamakoshi, and estimates travel mode choice models using travel diary data to reveal the constraint factors of mobility for elderly people. Finally, the paper focuses on important factors to shift travel mode from car passengers into an exclusive club bus system for elderly people.

2. TRAVEL SURVEY

2.1 Bus Operation in Surveyed Region

We conducted a case study for travel behavior research in a mountainous underpopulated region, Yamakoshi, in the city of Nagaoka, Niigata Prefecture. Yamakoshi has very heavy snowfall in winter located on the Japan Sea side of Japanese mainland (**Figure 1**), noted for not only the production of colored carps and good rice but beautiful landscapes of terraced rice field. It is one of the main region serious damaged by the Chuetsu Earthquake on October 23, 2004. All of community residents had to evacuate to urban flat areas in Nagaoka and could not return to their home until 2006. Population was 2,123 in Yamakoshi before the earthquake and is 1,407 in 2008 after the earthquake.

Since a private bus company stopped its operation inside of Yamakoshi region after the earthquake, the city managed to operate a free community bus provisionally examining a new

sustainable transport system. Because the private community bus would be planned to abolish in July 2008, the city conducted a study of bus operation and the NPO (Nonprofit Organization) of Chuetsu Frontier for Disaster Prevention introduced a social demonstration project of a new public transport system in July 2008. **Table 1** compares the details of bus operation between the provisional free service by the city and the exclusive club member service by the NPO. Since community buses in **Table 1** are (were) operated only inside of Yamakoshi region, bus users have to transfer to a private line-haul bus to visit shopping centers and hospitals in the urban area of Nagaoka and Ojiya.

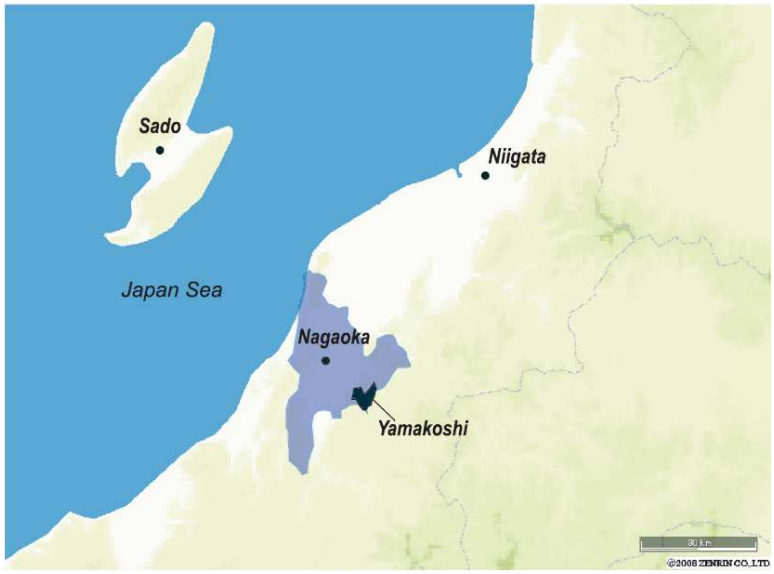


Figure 1 Survey region (City of Nagaoka, Niigata)

Table 1 Community bus operation in Yamakoshi

	Free community bus , Provisional operation	Exclusive club bus system, Social demonstration
Duration	Oct 2004 ~ June 2008	July 2008 ~ 2013 (dates to be arranged)
Administrator	City of Nagaoka and others	NPO (Chuetsu Frontier for Disaster Prevention)
Operator	Hired Car Association of Nagaoka	Private companies in Yamakoshi
Fare	Free	Membership fee 5,000 Yen per year, Free bus use
Financial support	Reconstruction Fund of Niigata	Reconstruction Fund of Niigata
Project cost	30 million Yen per year	26 million Yen per year
Number of route	4 routes (10 services per route)	4 routes (11 services per route)
Operation of private bus service	Suspension	Closure

2.2 Survey Method

We conducted a survey in August and September 2007 to understand travel behavior of residents in Yamakoshi. The following two kinds of questionnaire sheets were used in the survey.

***Basic survey sheet*:** Daily travel behavior and their preference to a community bus were studied for residents more than 15 years of age.

***Travel diary survey sheet*:** Detailed travel diary data for one week were collected for non-holders of a car license and elderly people. The survey covers all of the out-of-home trips including walking and strolling in the neighborhood.

There are two reasons why to execute such a detailed survey. 1) To collect data of short distance trips adequately. 2) To analyze day-to-day change of travel behavior in a week since the analysis by one-day data is demonstrated to be least reliable (Hanson and Huff, 1986). We should assume that travel behavior is very changeable depending on the day of a week. The basic survey collected the data of 261 individuals and the travel diary survey 90 individuals (totally 1,142 trips in a week).

2.3 Attributes and Primary Travel Modes (Basic Survey)

Yamakoshi is divided into 5 districts: *Tanesuhara, Mushigame, Takezawa, Higasi-takezawa and Napei.* **Table 2** shows the district distribution of inhabitants in Yamakoshi and individual samples of the basic survey. We collect 261 samples of inhabitants (18% of population) which are distributed almost proportional to the population of a district.

Table 2 District distribution of inhabitants and samples (the basic survey)

Districts	Households	Population	Samples
Tanesuhara	152	424 (29%)	60 (23%)
Mushigame	118	345 (23%)	67 (26%)
Takezawa	142	442 (30%)	68 (26%)
Higashi-takezawa	68	162 (11%)	35 (13%)
Nanpei	36	101 (7%)	31 (12%)
Total	516	1474 (100%)	261 (100%)

Table 3 shows the distribution of primary travel mode by sex, age, and trip purpose for the basic survey. Comparing the age composition of the samples with those of the whole Yamakoshi region, the chi-square value is 19.8 (χ^2=11.1 for d.f. =5 and p=0.05) revealing a little distortion. But, the number of samples for middle and older age (more than 60 years old) is good enough to use for the analysis of our objectives.

Table 3 also shows the composition ratios of travel mode by each attribute. The majority (78%) of men drive cars, while 39% of women drive cars and its 32% car passengers, and totally 71% of women are private car dependent. Bus users account for 24% of women, compared with 10% for men. Here, 'bus' includes a private line-haul bus connecting with the center of Nagaoka and a free community bus in the region. About 20% of age group of more than 60 years uses bus. One fifth (21%) of elderly people of more than 80 years choose walking, revealing many of them take short distance trips in their neighborhood.

Table 3 Primary travel modes by sex, age, and trip purpose

Attribute	Category	Car driver		Car passenger		Bus		Walk		Total
Sex	Male	92	*78.0%*	9	*7.6%*	12	*10.2%*	5	*4.2%*	118
	Female	55	*39.3%*	45	*32.1%*	34	*24.3%*	6	*4.3%*	140
	Subtotal	147	*57.0%*	54	*20.9%*	46	*17.8%*	11	*4.3%*	258
Age	10-19 years old	2	*25.0%*	2	*25.0%*	4	*50.0%*	0	*0.0%*	8
	20-59 years old	89	*80.9%*	15	*13.6%*	6	*5.5%*	0	*0.0%*	110
	60-69 years old	29	*61.7%*	8	*17.0%*	10	*21.3%*	0	*0.0%*	47
	70-79 years old	21	*38.2%*	19	*34.5%*	12	*21.8%*	3	*5.5%*	55
	80 years old or more	6	*15.8%*	10	*26.3%*	14	*36.8%*	8	*21.1%*	38
	Subtotal	147	*57.0%*	54	*20.9%*	46	*17.8%*	11	*4.3%*	258
Purpose	Work	88	*82.2%*	8	*7.5%*	4	*3.7%*	7	*6.5%*	107
	School	1	*12.5%*	2	*25.0%*	5	*62.5%*	0	*0.0%*	8
	Shopping	149	*61.6%*	66	*27.3%*	22	*9.1%*	5	*2.1%*	242
	Hospital	54	*40.6%*	30	*22.6%*	26	*19.5%*	23	*17.3%*	133
	Subtotal	292	*59.6%*	106	*21.6%*	57	*11.6%*	35	*7.1%*	490

Note: Respondents of 'sex' and 'age' are 258 samples excluding 3 samples without answers, showing their primary travel mode for each individual. Primary travel modes were also requested to answer by 'trip purpose', which yield 490 samples.

2.4 Individual Attributes and Trips (Travel Diary Survey)

Table 4 shows the proportion of individual attributes and the number of trips generated in a week based on the travel diary survey. Trip generation rate indicates men generate more trips than women. The age group of 20-59 years (10 individuals) includes only non-holders of a car license, while the age group of more than 60 years includes holders of a car license. Sample distribution by district is almost proportional to the population of each district. Average trip generation rate (1.81 trips per day) is slightly lower than usual. **Table 5** indicates the number of trips per week by travel mode based on the travel diary survey. The majority (86%) of car license holder choose 'car driver', while about one third (37%) of non-holders choose 'car passenger'.

Table 4 Individual attributes and trips (travel diary survey)

		Individuals	Trips/week	Trips/person/day
Sex	Male	41	624	2.17
	Female	49	518	1.51
Age	20-59 years old*	10	82	1.17
	60-69 years old	35	554	2.26
	70-79 years old	24	343	2.04
	80 years old or more	21	163	1.11
District	Tanesuhara	20	226	1.61
	Mushigame	21	214	1.46
	Takezawa	27	445	2.35
	Higashi-takezawa	11	100	1.30
	Nanpei	11	157	2.04
Car license	Holder	34	592	2.49
	Non-holder	56	550	1.40
Trip objective	Shopping	—	104	—
	Hospital	—	38	—
	Leisure	—	81	—
	Work	—	340	—
	Return to home	—	532	—
	Others	—	47	—
Total		90	1142	1.81

Note: *The age group of 20-59 years (10 individuals) is a non-holder of a car license.

Table 5 Number of trips per week by mode (travel diary survey)

Mode	License		Total
	Holder	Non-holder	
Car driver	508	0	508
Car passenger	22	202	224
Bus	12	99	111
Walking	50	249	299
Total	592	550	1,142

3. BARRIERS TO MOBILITY

3.1 Barriers to Community Bus Use

Figure 2 shows barrier factors to community bus use, dividing into the two age categories of

less than 70 years and more than 70 years. The analysis uses data of the basic survey (258 samples) where respondents were asked to choose three factors for improving bus services based on their priority. The figure shows the factors of the first and second priority only since many respondents did not choose the third priority. These are factors that respondents ask for improvement, namely barrier factors to bus use. Regardless of age, 'operation frequency' is the biggest barrier to bus use. Elderly people of more than 70 years old set much store on 'a low-floor vehicle' and 'walking environment to bus stop' because of their physical conditions. On the other hand, people of less than 70 years old show the tendency to taking into account 'operation frequency and fare'. Since the majority of bus users are elderly people, 'walking distance to a bus stop' is the second biggest barrier and we expect its improvement would increase bus use.

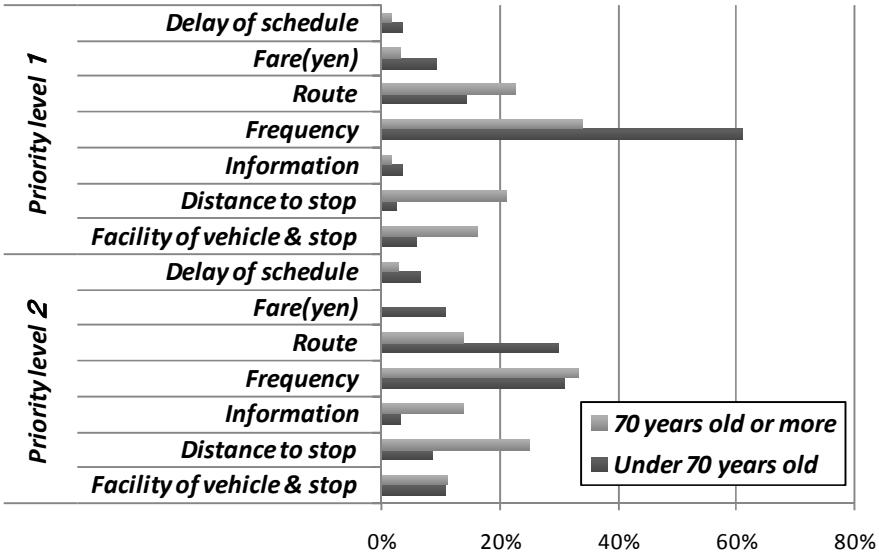


Figure 2 Barriers to bus use by age group

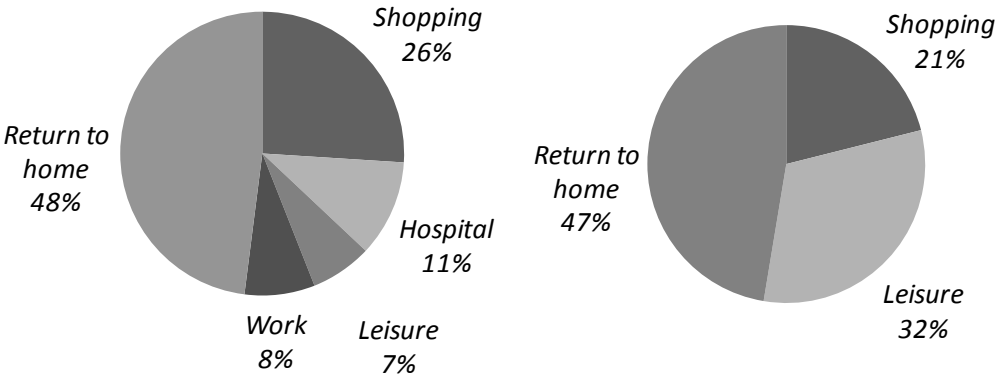
Figure 3 shows the proportion of satisfaction/dissatisfaction to bus service by daily travel mode (total 236 samples). Here, 'car passenger supplier' is a car driver serving car passengers of his/her family members or friends. Car passenger suppliers feel dissatisfaction to bus use as much as car passengers, while single car drivers and bus users feel more satisfaction to bus use than the others. The chi-square test reveals a significant difference of satisfaction between single car drivers and car passenger suppliers (the chi-square statistic is 22.37, while χ^2=9.925 for d.f.=2, p=0.01). Furthermore, there are significant differences among four groups (the chi-square statistic is 26.66, while χ^2=12.59 for d.f.=6, p=0.05). We would estimate car passenger suppliers feel as much as dissatisfaction because they serve car passengers regularly. 'Regular car passenger suppliers', who serve more than once per week, account for 39.7% of all car passenger suppliers and feel more dissatisfaction to bus use than all of car passenger suppliers. Modal shift of car passengers into bus use would create more satisfaction for bus users as well as regular car passenger suppliers in particular.

Figure 3 Satisfaction/dissatisfaction to bus service by travel mode

3.2 Behavior of Car Passenger and Car Passenger Suppliers

Table 5 indicates that trips by car passengers (224 trips per week) account for 20% of all trips based on the travel diary survey. By excluding trips for working in rice fields and on farms from 224 trips by car passengers, 100 trips (84%) of car passengers are served by their family members and 19 trips (16%) are served by their friends. The existence of family members who could drive a car is a significant condition for supplying the service of car passengers.

Figure 4 shows the proportion of travel purposes among trips by car passengers (totally 119 trips per week), separately in two cases where car passengers are served by family members (a left circle) or friends (a right circle). It seems to be difficult for car passengers to ask for ride sharing to friends (not to family members) when trip purposes are regular commuting and going to hospital. An interview survey toward 15 people indicates that car passengers feel constraint and uneasiness when they ask for ride sharing to friends for the purpose of their own business. One of feasible conditions for car passengers sharing with friends (not with family members) would be that space-time coincidence exists between them. Konno (1994) suggested that trips by car passengers are not-cycled trip chains from home to home. Our survey, however, indicates that not-cycled trips account for only 6.7% of car passenger trips. In Yamakoshi car passengers would play an important role as an effective home-based travel mode. It would be difficult to combine car passengers with other travel modes in a linked trip because of a low service level of bus and a steep mountainous region, and because walking environment to a bus stop is bad. Even though car passengers are usually served by their family members, ride sharing seems to be an unwilling task to a car driver.



(Left: family suppliers, 100 trips; Right: friend suppliers, 19 trips)

Figure 4 Proportion of trip purposes for car passengers

4. TRVEL MODE CHOICE

4.1 Estimation of Mode Choice Models

The multinomial logit models of travel mode choice are estimated using the one-week data of the travel diary survey. Since travel data have day-to-day variation and the share of bus mode is low (10%) with very low daily trips (average 16 trips per day by bus), all of one-week data are applied. The choice set of mode differs depending on whether an individual holds a car license or not. Holders choose from four modes (car driver, car passengers, bus, and walking) and non-holders from three modes (car passengers, bus, and walking). Explanatory variables used are as in the followings.

Constant:	Constant for a specific mode.
Time:	Travel time (minute).
Age:	Dummy variables of age are classified into the following four categories. *1)* ***20-50Years****: One from 20 to 59 years old (non-holders of a car license), and zero otherwise. 2)* ***60Years****: One from 60 to 69 years old, and zero otherwise. 3)* ***70Years****: One from 70 to 79 years old, and zero otherwise. 4)* ***Over80Years****: One for more than 80 years old, and zero otherwise.*
Sex:	One for male, and zero for female.
Dif.Passenger:	One when both of the following conditions are satisfied, and zero otherwise. *Condition-1: There is no car license holder (man & woman) of more than 60 years old in a household. Condition-2: There is no woman of a car license holder of less than 60 years old in a household.* (A man of a car license holder less than 60 years old supposedly does not stay in a house during the daytime.)

Limate: One when someone has a car license in a household, and zero otherwise
BSdist: One when a bus stop exists within 300 meters from a house, and zero otherwise.

The modeling mainly aims to represent the impact of travelers' age and car license holding, and the constraint of bus use. The variable of 'Dif.Passenger' would indicate the proposition that people are likely to choose 'car passenger' during the daytime when there is a car license holder in a household. Our study suggests that 'walking distance to a bus stop' is a big barrier for bus use since the majority of bus users are elderly people.

Table 6 shows estimated results of two models. Model-1 uses the whole effective samples of the travel diary survey (1,142 observations), and Model-2 uses only the trips of more than 60 years old (1,060 observations, excluding 82 trips by 20-59 years old of non-holders). Correlation coefficients between explanatory variables are so low that multicollinearity does not exist. Adjusted rho-squares are more than 0.7 for both models with a very high goodness of fit. **Table 7 and Table 8** show the hit ratios by mode for Model-1 and Model-2 respectively, where numbers in parentheses indicate the number of trips for non-holders of a car license. Total hit ratios as well as hit ratios by mode are very high.

Table 6 Estimation results of mode choice models

		Model-1		Model-2	
Mode	Variables	Parameters	t-values	Parameters	t-values
Common	***TIME***	-0.1581	-13.15	-0.2054	-13.04
Car	***Constant***	-3.492	-6.396	-2.250	-6.658
Car	***60Years***	1.734	3.406	-	-
Car	***70years***	2.634	4.823	-	-
Passenger	***Constant***	-1.688	-2.860	-4.482	-12.33
Passenger	***60Years***	-2.445	-4.047	-	-
Passenger	***70Years***	-1.502	-2.472	-	-
Passenger	***Over 80 Years***	-3.173	-4.243	-	-
Passenger	***Male***	-1.567	-4.606	-1.209	-3.676
Passenger	***Dif.Passenger***	-4.360	-10.42	-5.355	-10.52
Bus	***Constant***	-1.641	-3.626	-1.023	-2.511
Bus	***20-50Years***	3.012	4.707	-	-
Bus	***Male***	-0.4403	-1.203	-0.5035	-1.191
Bus	***Limate***	-1.851	-4.958	-0.7260	-1.897
Bus	***BSdist***	-0.7633	-2.135	-2.572	-6.823
Final log-likelihood		-391.27		-325.65	
Adjusted rho-squared		0.7149		0.7491	
Number of observations		1142		1060	

Table 7 Hit ratios by mode (Model-1)

		Observation				Total	Hit Ratio
		Car driver	Car passenger	Bus	Walking		
Estimation	Car driver	508	22	8	6	544	93.4%
	Car passenger		173(173)	34(30)	2(2)	209(205)	82.8%
	Bus		12(12)	68(68)	2(2)	82(82)	82.9%
	Walking		17(1)	1(1)	289(245)	307(263)	94.1%
Total		508	224(202)	111(99)	299(249)	1142(550)	93.2%

Note: Numbers in parentheses indicate the number of trips for non-holders of a car license.

Table 8 Hit ratios by mode (Model-2)

		Observation				Total	Hit Ratio
		Car driver	Car passenger	Bus	Walking		
Estimation	Car driver	508	22	8	6	544	93.4%
	Car passenger		132(132)	20(20)	2(2)	154(154)	85.7%
	Bus		10(10)	60(60)	2(2)	72(72)	83.3%
	Walking		9(9)	1(1)	280(236)	290(246)	96.6%
Total		508	173(151)	89(81)	290(240)	1060(472)	92.5%

Note: Numbers in parentheses indicate the number of trips for non-holders of a car license.

Both models reveal that the choice of car passengers is strongly influenced by the fact whether family members with a car license are at home or not during the daytime. Men are not likely to choose car passengers, since their percentage of holding a car license is high. As for a bus mode, people are not likely to use bus when their family members hold a car licenses. Looking at the parameters of 'BSdist' (distance to a bus stop) and 'Limate' (car licenses in a family), the absolute value of parameters are |Limate|>|BSdist| for Model-1, and |Limate|<|BSdist| for Model-2 including elderly people only of more than 60 years. Model-2 indicates that elderly people feel a strong barrier to the distance to a bus stop, which is clearly a big factor of obstructing bus use.

4.2 Discussion

First, this section analyzes the sensitivity of two variables 'distance to a bus stop' and 'bus travel time' by using Model-2 including elderly people only of more than 60 years. The distance to a bus stop from home was distributed around from 300 to 500 meters in Yamakoshi in case of the free community bus in 2007. **Figure 5** shows the change of choice probability from the current situation assuming that a bus stop exists within 300 meters from home for all observations. The choice probability of bus increases from 6.8% to 13.4% (6.6%

points increase) when a bus stop exists within 300 meters from home.

Figure 6 also shows the change of choice probability from the current situation when bus travel time decreases by 5 and 10 minutes for all observations. Then, the choice probability of bus increases from 6.8% to 8.1% (1.3% points increase) by 5 minutes decrease, and from 6.8% to 14.0% (7.2% points increase) by 10 minutes decrease. Bus travel time decreasing by 10 minutes is required to achieve almost the same effect as decreasing distance to a bus stop within 300 meters. It is actually very difficult to decrease bus travel time in Yamakoshi because of narrow width of roads and short route length of bus (about 13 km for the longest route). Since long walking distance to a bus stop is a strong resistance to elderly people, decreasing distance to a bus stop is a more feasible and effective measure to raise bus users.

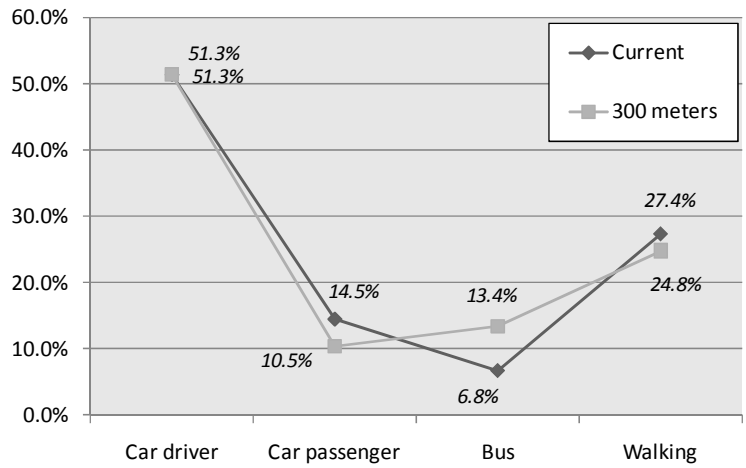
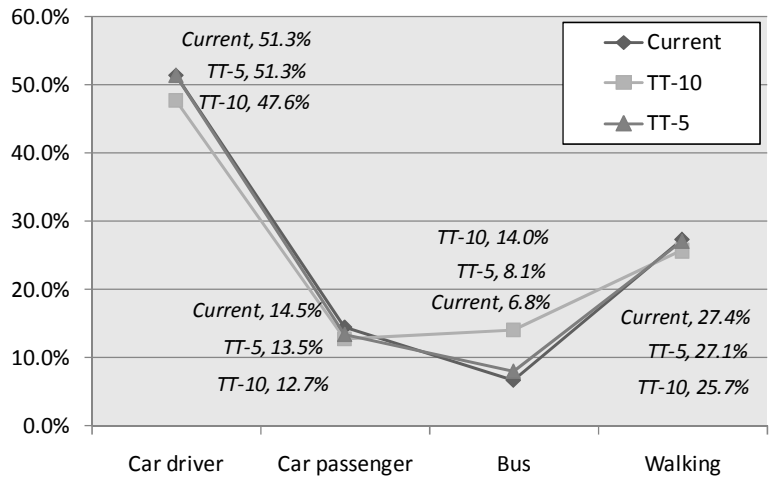


Figure 5 Probability change by 300 meters distance to a bus stop



(TT-5: decreasing by 5 minutes of bus travel time; TT-10: decreasing by 10 minutes)

Figure 6 Probability change by decreasing bus travel time

The exclusive club bus system operated in Yamakoshi after July 2008 (see Table 1) adopts a flexible routing method such that a community bus makes a detour and stops at a nearer place from a user house. This operation results in decreasing the longest walking distance from home to a bus stop to less than 300 meters. Average patronage of the club bus system was about 3,000 trips per month in 2008. This number is about double of the free community bus which was operated provisionally just after the earthquake. Our interview toward 12 club members indicates that a new flexible routing is one of the most influential factors to increase bus users. These statements also support the findings of our research such that one of the most important barriers to use community bus is a walking distance from home to a bus stop.

As already shown in Table 1, there is an institutional difference between the free community bus and the exclusive club bus system. The NPO of Chuetsu Frontier for Disaster Prevention tried its best successfully persuading all community householders to join the exclusive club bus system. Club members must pay its membership fee of 5,000 Yen per year, but members' bus use is free. This fee system economically suggests that once club members pay the fixed membership fee, they are inclined toward more and more bus use. The exclusive club system offers to club members not only an economic incentive of using a free bus more frequently but also a psychological incentive to support and encourage their "own" bus system. Although these economic and psychological incentives would play an important role to increase bus use, the paper demonstrates that walking distance from home to a bus stop is also one of the most important barriers to use a community bus.

5. CONCLUSION

The paper articulates the following points about the mobility by car passengers and community buses for elderly people in a mountainous underpopulated region, Yamakoshi, Niigata in Japan.

- Regular car passengers are likely to feel dissatisfaction toward bus services.
- 89% of car passenger transport are supplied by family members rather than friends. This fact imposes barriers to modal choice of car passengers.
- In case of car passengers supplied by friends, it is difficult to ask for ride sharing for the purpose of their own business.
- Walking distance from home to a bus stop is the most important barriers to use a community bus in a mountainous region
- The flexible route operation of an exclusive club bus system, which results in decreasing walking distance to a bus stop, is one of the reasons why bus patronage has doubly increased.

The paper discusses the structural barriers and constraints of mobility in a mountainous

underpopulated region, and reveals that the flexible route operation of an exclusive club bus system is one of the reasons why bus patronage has doubly increased. Additionally it may be true that the exclusive club system offers to club members economic and psychological incentives to support and love their "own" bus system. On the other hand, Handy and Niemeier (1997) indicates that it is difficult to understand the needs of latent activity based on the analysis of actual behavior data under the low level of service in an underpopulated region. The paper discusses the possibility to investigate the latent needs of bus service for elderly people. Still, further research is needed on the economic and psychological incentives of a club system as well as the latent needs of transport demand in an underpopulated region.

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