SPECIAL BUS SERVICE PLANNING FOR IMPROVING MOBILITY OF ELDERLY PEOPLE CONSIDERING TRAVEL EFFORT

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abstract: This study aims to examine basic issues on Special bus service planning to enhance transportation mobility for elderly people in Japan, considering characteristics of travel behavior and effort. The main purpose of this paper is to estimate the coefficients of generalized time and the value of time reflecting travel effort. Consequently, the equivalent time coefficients of travel mode are ranked in the following order; car<train sitting<taxi<bus sitting<bicycle<motor-cycle<train standing<waiting<bus standing <walking.

1.INTRODUCTION

Public transportation service for elderly people and disabled persons in Japan is poor comparing with European countries like Sweden, German, United Kingdom and so on, even if Japan has some economical subsidies from many local governments and transportation service agencies to them, which are to discount fare of public transportation including taxi, elevators and escalators in many railway stations have been gradually installed and buses with lift have been serviced.

On the other hand, the population ratio of elderly people over 65 years old is increasing with unprecedented rapid speed and has become over 15% at present. Its ratio is forecasted to be over 20% in early 21st centuries. These social conditions require us to improve public transportation service and enhance the level of its service.

Especially, this study focuses on bus service in public transportation system. Despite of main transportation mode for elderly people, they feel more difficulty to use bus, because of low frequency, long distance to bus stop, congestion, high steps and so on, than ordinary people feel.

In European countries, various bus service improvement trials have been done to overcome these difficulties. Special transport service system like Dial-a-ride in UK, Service Route in Sweden and low floor ordinary-bus in German, Denmark and Sweden are famous relating to these trials.

Therefore this study aims to examine basic issues on "Special Bus" service planning to enhance transportation mobility for elderly people in Japan, considering characteristics of travel behavior and effort. In this paper, the "Special Bus " means the improved bus for elderly people to use it more easily than ordinary bus.

The purpose of this paper is as follows; the first is to clarify the travel behavior of elderly

people and point out transportation problems, the second is to examine what elderly people wish on the introduction of Special Bus, the third is to show how to evaluate transportation service by using generalized time, the fourth is to estimate the coefficients of generalized time and the value of time reflecting travel effort, and the fifth is to consider what special bus service should be. Especially, the main target of the paper is placed on the fourth purpose shown above.

2.CONCEPT OF SPECIAL BUS AND PURPOSE OF THIS STUDY

2.1 Concept of Special Bus

Special transport service in European countries and the United States of America indicates the public transportation service which are provided to people who can not use ordinary public transportation because of their handicap. Especially, this system often means "door-to-door" service system.

Bus service system in this paper does not indicate the "door-to-door" special transport system exactly, but it falls into improved ordinary bus service system. Considering this kind of system, "Service Route" in Sweden gives many information. Service Route is the ordinary bus service to provide elderly people and the disabled the enhanced bus service for their mobility. This service focuses on to pick up travel demand between ordinary bus and special transport by supplying routes, schedule and vehicle corresponded to elderly people and the disabled characteristics.

We can suggest the characteristics of Special Bus system considered in this paper is like follows:
1)Users: mainly elderly people and the disabled, including ordinary people.
2)Vehicles: non-step bus, low floor bus with lift.
3)Routes: routes connecting resident area, public facilities(hospital, health center, cultural center, city office, station etc.) and shopping centers.
4)Bus stop interval: shorter distance in comparison with ordinary bus, like 200m.
5)Fare: cheaper for elderly people and the disabled.

2.2 Issues on Special Bus Service Planning

Issues which are examined on Special Bus planning are as follows;
1)to clarify the characteristics of travel behavior of elderly people and pick up transportation problems relating to mobility,
2)to capture the relation between transportation problems and present transportation system, and pick up transportation problems relating to mobility,
3)to clarify the position of Special Bus in present transportation system and make the concept of Special Bus system,
4)to capture public attitudes to Special Bus and make agreement on its introduction,
5)to build bus service system reflecting the characteristics of travel behavior of elderly people,
6)to build the travel demand forecasting method for Special Bus,
7)to build the comprehensive method of estimating effectiveness and evaluation, including both of users and suppliers, and
8)to examine social system relating to law, administration and finance.
In this paper, issues relating to 1, 2 and 3 shown above are examined.

3.CHARACTERISTICS OF TRAVEL BEHAVIOR OF ELDERLY PEOPLE

3.1 Outline of Surveys

Questionnaire survey was done to elderly people in Suita city of Osaka prefecture, in order to answer the following questions:
Would the Special bus contribute to enhance mobility of elderly people?
What kind of travel behavior do elderly people have in ordinary life?
What kind of transportation problem do they have?
What do they think about Special Bus service?

This survey was carried out in January 1992 in the way of visiting residents and delivering sheets, and collecting these sheets after several days. Then, Suita city was divided into 215 zones and these zones were classified into 12 types by characteristics of distance from station and bus stop. Moreover, one zone was selected in each type and 50 households was randomly sampled in each zone. The survey sheets were delivered to all persons who were older than 60 years old and to one person of less than 60 years old, too.
Number of delivered sheets and available collected sheets are as follows;
[elderly people] 818 sheets delivery, 758 sheets collected and its ratio 93%,
[not elderly people] 388 sheets delivery, 297 sheets collected and its ratio 77%.
Here, elderly people indicate people who are 60 and older than 60 years old.

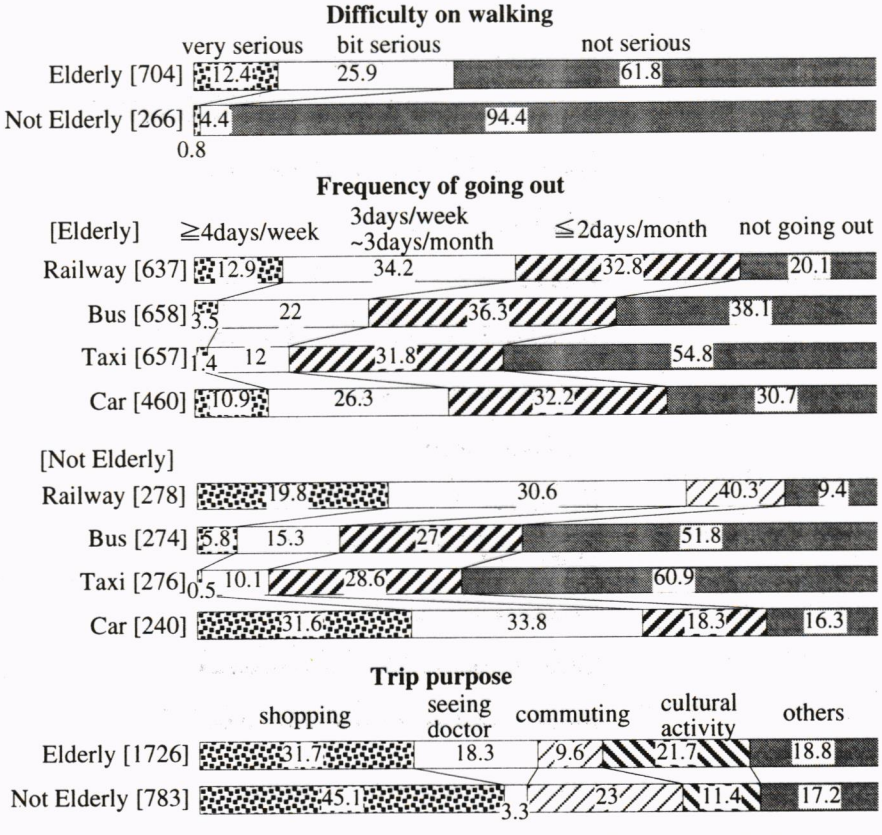


Fig.1. Comparison of travel behavior between elderly people and others.

3.2 Characteristics of Travel Behavior

Figure 1 shows characteristics of travel behavior of elderly people in comparison with not elderly people.

Difficulty on walking and frequency of going out
The 40% of elderly people feels the difficulty of walking when going out. On the other hand, not elderly people do not feel so much. Only 5% feels difficulty on walking.
Frequency of going out
Comparison of frequency of going out by each travel mode shows that railway is the highest for the elderly with following car, bus, and taxi. Not elderly people shows the same order but the frequency of railway and car is more than it for the elderly. On the other hand, elderly people use bus and taxi more than not elderly people.
Trip purpose
Elderly people shows that the ratios of seeing doctor and cultural activity are higher than those for not elderly people. However, shopping and commuting are less.

3.3 Problems on Present Bus Service

Problems on present ordinary bus service that elder people and not elderly people pointed out are shown in Figure 2.

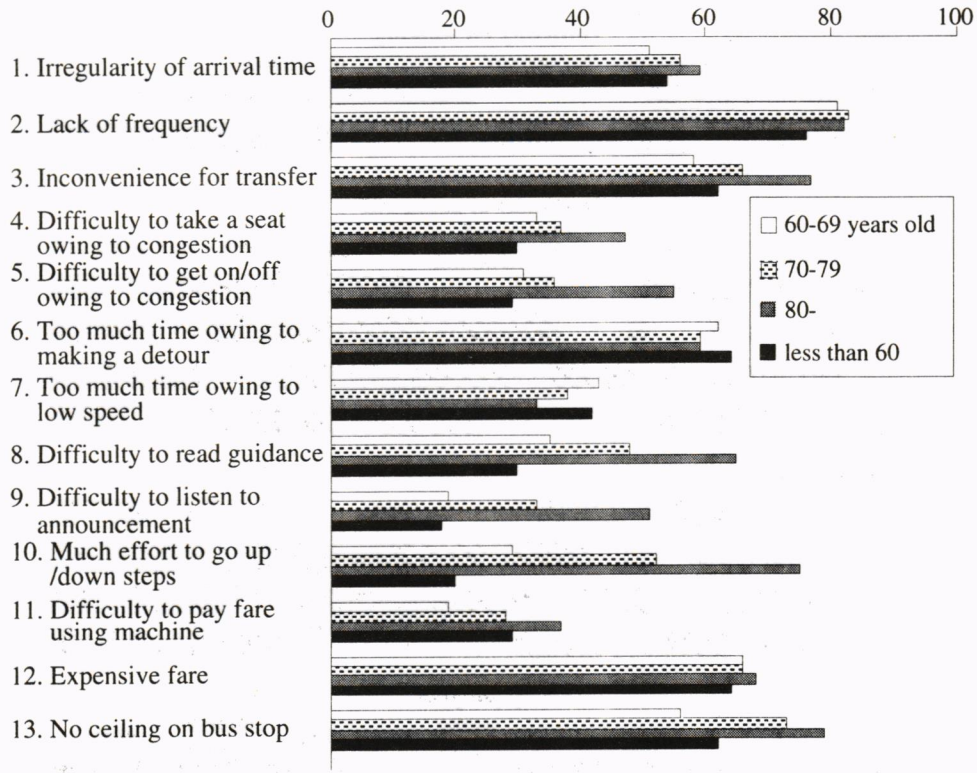


Fig.2. Problems on present bus service.

Both of them show the following aspects as problems on bus service;
1)irregularity of arrival time,
2)lack of frequency,
3)inconvenience for transfer,
4)too much time owing to making a detour, and
5)expensive fare.
Moreover, things they show much more complaints as age increases are as follows;
1)inconvenience for transfer,
2)difficulty to take a seat and get on/off owing to congestion,
3)difficulty to read guidance and listen to announcement,
4)much effort to go up/down steps, and
5)difficulty to pay fare using machine.
These complaints seem to relate to their physical conditions.

In addition, the results of this survey shows that those who want to quit to use bus by the reason of physical condition reached to 11% of elderly people, especially people over 70 years old having 20%.

3.4 Wishes to Use Special Bus

The characteristics of travel behavior of elderly people obtained from this survey shows that many of them have much difficulties on travelling although they wish to go out. However, the present bus does not supply enough service to enhance their mobility. They have much complaints on present bus service. Moreover, there are many elderly people who are not willingly to use it.

The role of Special Bus planned in this paper is to supply service which overcomes such complaints shown above and to capture those who want to quit to use bus, or can not use it although they want to use it. Therefore, we planned Special Bus which had such characteristics shown in 2.2. Public attitudes to this bus shows in Figure 3.

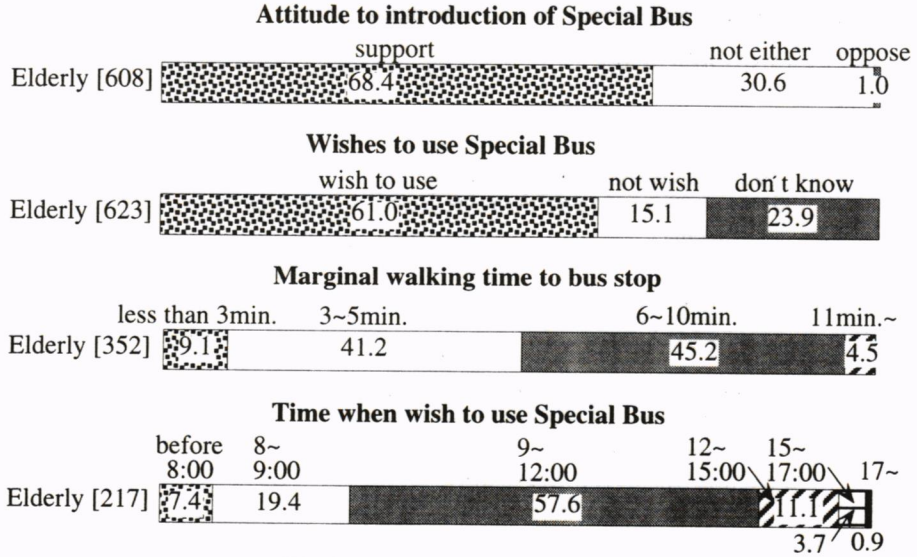


Fig.3. Wishes to use special bus.

Attitude to introduction of special bus
People who support the introduction of Special Bus share about 70% in the elderly. There is a few opposition people.

Wishes to use Special Bus
Those who wish to use Special Bus, under the condition that a bus stop exists nearby their home with walking time less than the following marginal walking time, share 60% of them.
Marginal walking time to bus stop and frequency
The 3 to 5 minutes class and 6 to 10 minutes one have the highest share of over 40%. The frequency they wish are like that one per a hour is the highest(44%), following one per 30 minutes(30%) and one per two hours(17%).

Time when wish to use Special Bus
Time when they wish to use Special Bus shows that 9-12 o'clock is the highest(about 60%), following 8-9 and 12-15. Moreover, the day time of 9-17 o'clock shares about 70%. Elderly people seem to have characteristics of using Special Bus during the time except rush hours.

Price of fare and who should bear cost ?
In the price of fare, elderly people desire 200-250yens most and the next is 100-150. As present price is about 200yens, they seem to be divided into two groups who one desires almost the same price as the present one, and the other desires half of the present price. In the point of who should bear the running cost of bus, half of them think that both public sector and users should bear, and 33% of them support to public sector bearing all cost. There is few in " Users should bear all cost".

4.METHOD OF BUS SERVICE EVALUATION USING GENERALIZED TIME

4.1 Generalized Time Model

Nitta, one of co-authors, suggested the following model as the travel mode/route choice model [Mohri and Nitta(1984), Nitta(1984), Nitta *et al*(1986)] ;

$$P_A = 1 / (1 + \exp (a\Delta G + b),$$
$$P_A + P_B = 1 \qquad (1)$$
$$\Delta G = G_B - G_A$$

where, P_I = the probability of selecting the route I,
G_I = the generalized time of the route I, and
a,b = coefficients.

Then the generalized time G can be written as;

$$G = \Sigma \mu_i t_i + \mu_e N + M/\lambda \qquad (2)$$

where, μ_i = the equivalent coefficient of travel mode i,
μ_e = the equivalent coefficient of one transfer,
λ = the value of time,
t_i = the time spent on travel mode i,
N = the number of transfer, and
M = total travel cost.

4.2 Method of Bus Service Evaluation

By using generalized time, you could easily evaluate the alternatives of bus service. Because you could evaluate the bus service including the time spent on each different travel mode, the number of transfer and cost by the unit time of generalized time. Considering new bus system like Special Bus in this paper, the following cases cold be picked up as the evaluation of bus service.

Case 1: Evaluation of alternatives of new bus service planning
Evaluating alternatives of bus service planning, main factors become allocation of routes and bus stops, frequency, speed, fare, the number of transfer, possibility of taking a seat and so on. In order to incorporate these factors with generalized time, time spent sitting on bus, time spent standing on bus, waiting time, walking time to bus stop, the number of transfer and fare would be important variables of generalized time. By using coefficients corresponding to each travel mode and value of time, generalized time could be calculated. This generalized time can be obtained in both cases of the individual and the aggregated. Like this, it would become to evaluate each alternative of bus service in both cases of individual user and aggregated group.

Case2: Evaluation of new bus service in comparison with present transportation service
How to evaluate the new bus service in comparison with present transportation service, like railway and ordinary bus, is the same as the way shown in Case 1. Comparing with railway service, time spent sitting on a train and time spent standing on it can be necessary.

5.ESTIMATION OF COEFFICIENTS OF GENERALIZED TIME

5.1 Objective of This Analysis

When you travel on foot or by bus, train, bicycle and so on, even if each travel mode has the same time, the effort you feel on each travel mode is different. In this case, we have shown that the generalized time is useful to evaluate different transportation service in before chapters. Then, equivalent time coefficients and value of time must be obtained in order to calculate generalized time.

5.2 Outline of Surveys

Questionnaire survey was done to elderly people and not elderly people of Suita city in November, 1992, and to those of Hirakata city in December, 1996, in order to estimate equivalent time coefficients and value of time. The survey sheets were delivered to all persons who were older than 60 years old.
Number of delivered sheets and available collected sheets are as follows;
in Suita, 665 sheets were delivered, 600 sheets were collected and its ratio was 90%, and
in Hirakata, 636 sheets were delivered, 528 were collected and its ratio was 83%.

5.3 Method of Estimating Equivalent Time Coefficients

Equivalent travel time coefficient is the coefficient to convert the travel time of each travel mode and the number of transfer into the time of standard travel mode, which is travel time sitting on a train in this paper. For example, if the coefficient of time standing on a train is 2, 10 minutes spent standing on a train equals to 20 minutes of sitting on a train.

To estimate coefficients like this, some questions were thrown to elderly people. In the case of the coefficient of time spent standing on a train, information was obtained through a questionnaire shown in Figure 4, in which respondents select either A or B as preferable.

[Question]

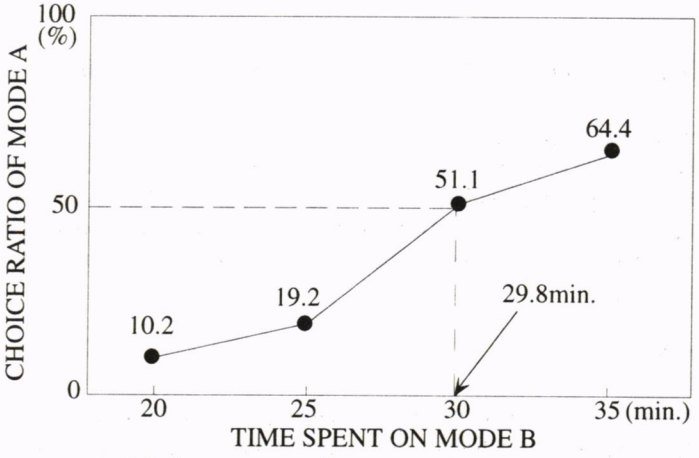
Which do you think to prefer and use, A or B,
when you travel in ordinary life ?

(Example)

1. A=15min. spent standing on a train	B=20min. spent sitting on a train
2. A=the same as the above	B=25min. spent sitting on a train
3. A=the same as the above	B=30min. spent sitting on a train
4. A=the same as the above	B=35min. spent sitting on a train

Fig.4. Question for estimation of equivalent time coefficient.

The time sitting, x is taken at four levels: 20, 25, 30 and 35 minutes. Then, the ratio of respondents preferring standing to all respondents is calculated at each x point, and the value of x corresponding a 50/50 split is obtained from Figure 5, by using straight line interpolation. This value is 29.8 minutes, leading to the coefficient of time spent standing on a train being 1.99(=29.8/15).



A=15min. spent standing on a train
B=*x*min. spent sitting on a train

Fig.5. Mothod of estimating equivalent time coefficient.

5.4 Estimation Results

The value of estimated coefficients of travel modes are shown in Table 1(Suita) and Table 2(Hirakata). The estimated coefficients for total data in Table 1 rank the modes in the following order: train sitting(standard mode=1), taxi(1.09), bus sitting(1.44), train standing(1.99), waiting(2.62), bus standing(3.04) and walking(3.73). In addition, the coefficient of single transfer is big and equals to 20.05 minutes on sitting train.

Table 1. Equivalent time coefficients in Suita.

		train	bus		taxi	walk	wait	single
		stand	sit	stand				transfer
gender	male	1.96	1.48	2.97	1.15	3.62	2.65	18.95
	female	2.02	1.39	2.83	1.02	3.81	2.56	20.74
age (years)	60-64	1.94	1.17	2.31	0.83	2.82	2.18	16.04
	65-69	1.95	1.40	2.90	1.31	3.57	2.54	17.82
	70-74	1.93	1.60	3.13	1.21	4.10	2.85	22.21
	75-79	2.08	1.40	3.20	1.10	4.63	2.59	20.50
	80-	2.35	1.75	4.38	1.14	4.67	3.11	37.19
occupation	with job	2.00	1.39	2.95	1.26	3.23	2.72	17.61
	housewife	1.92	1.24	2.44	0.99	3.03	2.26	16.29
	without job	2.00	1.47	3.06	1.07	4.04	2.56	21.24
living condition	good	1.97	1.42	2.96	1.06	3.55	2.60	19.19
	bad	1.99	1.13	2.21	1.36	2.95	2.07	19.43
	not either	2.02	1.65	3.52	1.13	5.04	2.97	23.21
health	good	1.95	1.40	2.76	1.13	3.36	1.78	18.55
	bit bad	1.97	1.48	3.20	1.09	3.89	1.88	21.91
	bad	2.28	1.45	3.29	0.99	4.72	1.75	21.40
difficulty on walking	serious	2.74	1.59	4.69	0.85	5.97	2.60	31.85
	bit serious	2.46	1.57	3.93	1.16	4.11	2.86	22.86
	not serious	1.88	1.23	2.40	1.06	3.04	2.32	16.10
car license	with	1.99	1.40	2.91	1.03	3.43	2.69	18.44
	without	2.00	1.43	2.97	1.10	3.83	2.54	20.55
car	with	2.02	1.35	2.88	0.98	2.56	2.43	18.39
	without	1.95	1.51	2.98	1.22	4.01	2.81	21.73
car use	A*)	1.94	1.31	2.88	1.12	3.24	2.71	17.68
	B*)	2.10	1.37	3.23	1.01	3.97	2.49	20.65
	C*)	1.95	1.51	2.85	1.14	3.86	2.68	20.98
total		1.99	1.44	3.04	1.09	3.73	2.62	20.05

*)A=possible to drive a car,
B=impossible to drive, but possible to use, and
C=impossible to drive and use

Table 2. Equivalent time coefficients in Hirakata.

		bus	taxi	walk	car	bicycle	motor	wait	single
		stand					cycle		transfer
age (years)	60-64	2.32	2.88	4.22	1.14	1.30	1.44	2.33	17.65
	65-69	2.62	2.00	4.92	1.11	1.51	—	2.87	19.27
	70-74	2.74	1.84	4.74	0.91	1.83	2.76	2.59	21.41
	75-79	2.72	—	4.18	1.73	—	—	2.59	20.32
	80-	—	1.15	5.04	0.62	0.69	—	2.52	30.24
gender	male(-64)	2.29	2.64	3.95	0.82	1.92	2.00	2.78	17.04
	female(-64)	2.46	1.30	4.09	0.82	1.60	1.63	2.46	18.96
	male(65-)	2.64	4.59	4.87	1.07	1.25	2.55	2.59	18.82
	female(65-)	2.84	1.47	4.75	0.85	1.74	2.64	2.68	25.00
	male	2.52	—	4.45	0.95	1.63	2.07	2.68	18.07
	female	2.61	1.35	4.31	0.84	1.66	1.68	2.55	20.71
total		2.58	1.53	4.35	0.85	1.64	1.92	2.59	19.84

On the other hand, Hirakata data include travel modes which were not objected in Suita survey, such as car, bicycle and motor-cycle. Coefficients in Table 2 rank the modes in the following order; train sitting(1), car(0.85), taxi(1.53), bicycle(1.64), motor-cycle(1.92), bus

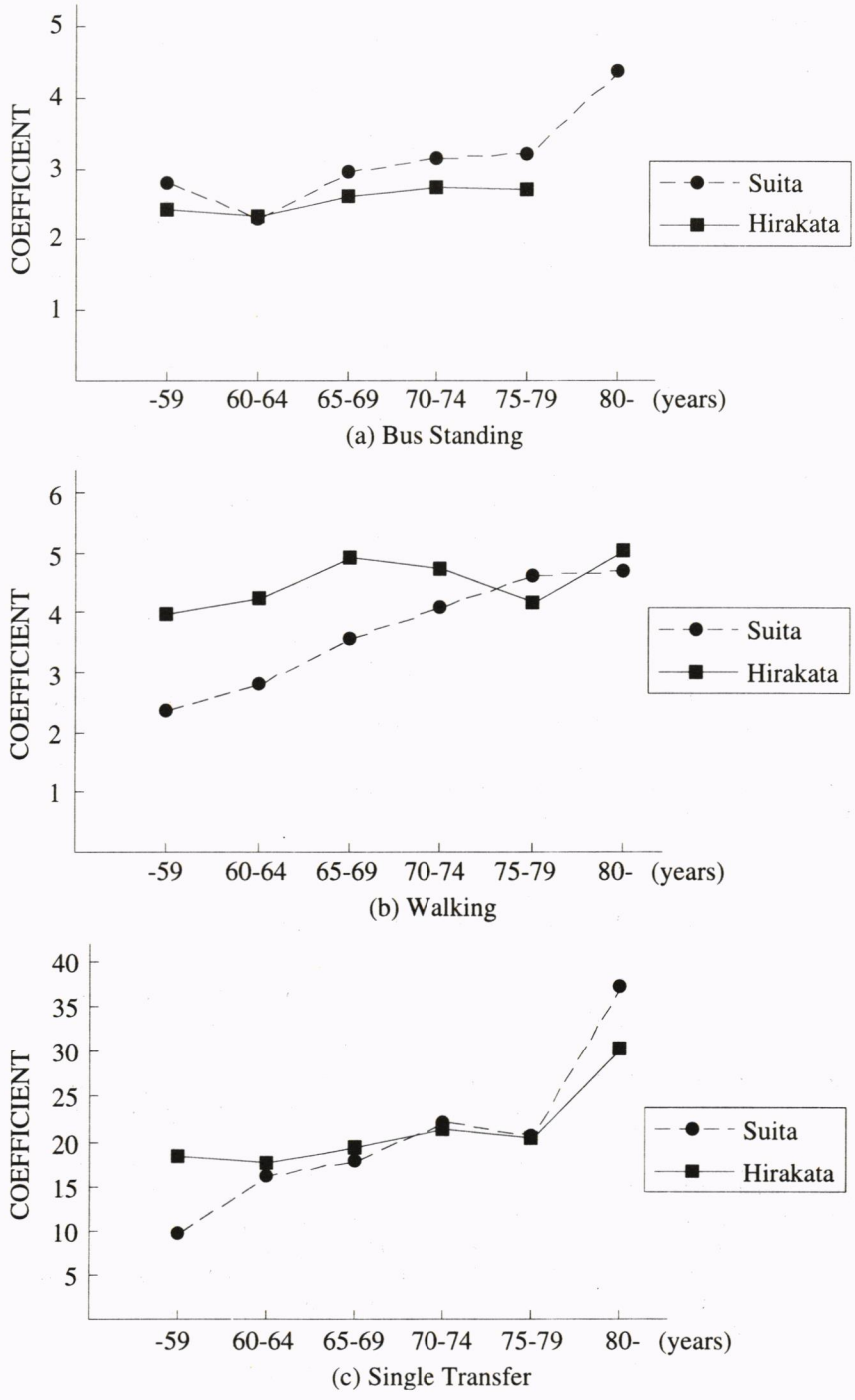


Fig.6. Comparison of equivalent time coefficients between age.

standing(2.58), waiting(2.59) and walking(4.35). Single transfer is 19.84, which are the same as one in Suita.

In comparison with both coefficients of Suita and Hirakata, coefficients can be ranked in the following order; car(0.9), train sitting(standard mode=1), taxi(1.1-1.5), bus sitting(1.4), bi-cycle(1.6), motor-cycle(1.9), train standing(2.0), waiting(2.6), bus standing(2.6-3.0) and walking(3.7-4.4). Efforts on standing, waiting and walking are bigger and seem to be more than two or three times of effort on sitting on a train. On the other hand, car and taxi are small and surprisingly bicycle and motor -cycle are relatively small.

Choosing bus standing, walking and single transfer whose have large effort to travel, the change of these coefficients with age increasing are shown in Figure 6. Bus standing shows that its coefficient become rapidly bigger over 75 years old. Walking in Suita shows that its coefficient gradually increase with age, but Hirakata does not show the same characteristics but has the higher and relatively stable value. Single transfer has almost the same characteristics in Suita nd Hirakata. Its coefficient gradually increases from 60 years old to 79 and rapidly go up over 80 years old. Moreover, Table 1 shows that the difficulty on walking affects travel effort on standing on train/bus, walking and transfer strongly.

6.ESTIMATION OF VALUE OF TIME

6.1 Method of Estimating the Value of Time

The value of time(VOT) is estimated for users by bus sitting. The survey for this estimation was the same respondents as those of Suita shown in the previous section 5.2. The question in relation to estimating the VOT is represented in Figure 7. In this case, the VOT is estimated for time-cost trader. The method of estimating the VOT is almost similar to that of the equivalent time coefficients in the section of 5.3.

We shall assume that there two bus lines between the place of P to Q with the different travel times and fares shown in Figure 7. One is cheaper but slow, and the other is faster but expensive. Then, each correspondent must answer the question as " How much do you admit to pay for the faster bus, when you use it ?".

[Question]

Now, there are two bus lines from P to Q.
One(A) has 30min. of travel time and ¥200 of fare.
The other(B) is faster(20min.) but more expensive.
How much do you admit to pay for the faster bus(B),
when you use it ?

1. ¥200	2. ¥240	3. ¥260	4. ¥280
5. ¥300	6. other (¥____)	7. not use	

Fig.7. Question for estimating VOT.

If the choice ratio of Bus A changes corresponding to the fare of Bus B, shown in Figure 8, then the fare of Bus B corresponding to a 50/50 split takes 239.3 yens. Therefore the VOT

can be calculated by the next equation.
VOT = (239.3-200)/(30-20) = 3.93 yens /minutes.

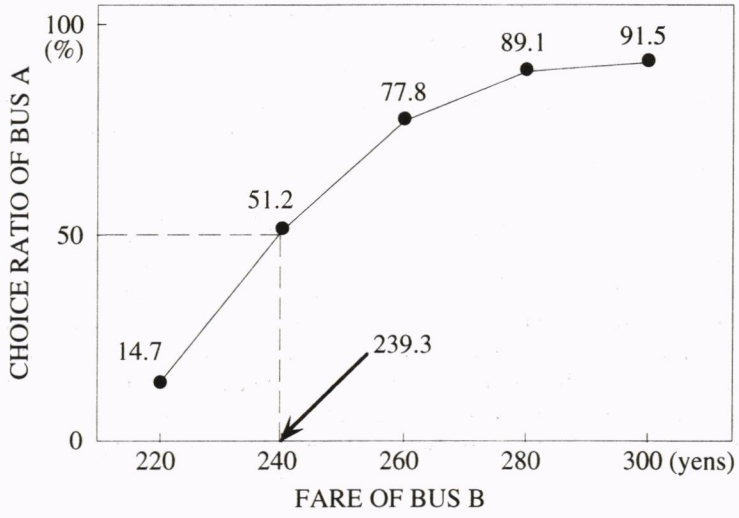


Fig.8. Method of estimating VOT.

6.2 Estimation Results

By using the method shown above, we estimated various VOT for each attitude of respondent, shown in Table 3. This table shows that people who have the higher VOT are like those who are wealthy, with job or car, or can drive. People who are handicapped on walking or not healthy have lower VOT. Like this, VOT for people who have higher mobility seem to become higher.

Table 3. Estimated VOT. (yen/min.)

gender	male	3.93	health	good	4.15
	female	3.94		bit bad	4.00
				bad	3.35
age (years)	60-64	4.18	walking difficulty	serious	3.66
	65-69	3.90		bit serious	4.12
	70-74	4.06		not serious	3.96
	75-79	3.81	car	with	4.01
	80-	3.70		without	3.86
occupation	with job	4.44	car license	with	4.45
	housewife	3.83		without	3.83
	without job	3.82			
living condition	good	4.57	car use	A*)	4.79
	bad	3.26		B*)	3.78
	not either	3.40		C*)	3.88

*)A=possible to drive a car,
B=impossible to drive, but possible to use, and
C=impossible to drive and use

7.CONCLUSIONS

The some interesting and important results have been obtained from this study.
Concerning problems on present bus service and wish to Special Bus,
1)the 40% of elderly people feel the difficulty on walking,
2)problems on present bus service for elderly people are strongly shown in transfer, congestion in bus, steps, guidance and announcement and so on,
3)the 70% of elderly people support the introduction of Special Bus, and 60% of them wish to use it if it were introduced, and
4)however, if the bus stop were more than 5 minutes on walking far from home, 50% of them do not want to use it.

Regarding the estimation of coefficients of generalised time which is the main purpose of this paper, the following issues have been derived.
1)The equivalent time coefficients of travel mode estimated are ranked in the following order: car<train sitting<taxi<bus sitting<bicycle<motor-cycle<train standing<waiting<bus standing <walking.
In addition, that of single transfer is great and equals to 20 minutes on train sitting.
2)Observing these coefficients by the aspects of individual attitudes and mobility, coefficients of bus standing, transfer and walking become higher as they become older, or as their difficulty on walking become more serious.
3) People who have the higher VOT are like those who are wealthy, with job or car, or can drive. People who are handicapped on walking or not healthy have lower VOT.

Considering these results, the following aspects on Special Bus planning can be pointed out:
1)Every elderly people can sit,
2)Bus stops locate nearby their home and public facilities, and
3)People can go without transfer, even if it takes so much.

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