

**AN EVALUATION OF THE QUALITY OF SERVICE  
AND COST-EFFECTIVENESS OF  
SPECIAL TRANSPORT SERVICE IN THE TOKYO METROPOLITAN AREA**

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abstract : Although in recent years the government and other self-governing bodies grant financial aid to the private sector for providing ST service, there is no method for judging the performance of each provider in order to determine proper subsidies. The same is true when a contractor is chosen. Also, there is no effective way to monitor the quality of service of current providers. Upon this background, this paper discusses , a) the current implementations of door-to-door service in Japan, b) an evaluation of the quality of ST service from the viewpoint of the users, c) analysis of the cost-effectiveness of ST service.

## 1. INTRODUCTION

Since the early 1970's, special transport service (ST service ) has been operated in Japan in order to provide mobility for wheelchair users and other severely disabled persons. ST service was expanded during a nation-wide campaign in 1977, and "The Year of Disabled Persons" in 1981 provide an opportunity to rapidly implement the service throughout the country. With the expansion of ST service during the 1980's, barriers were removed in the public transportation field providing increased mobility of the elderly and disabled persons. Since 1990, various types of ST service have been implemented to encourage independent living of drastically increased number of elderly persons. Currently, in addition to further expansion of ST service for mobility handicapped persons, improvement in the quality of

service is needed.

The door-to-door service which is commonly known as "Handicab" in Japan has been operated by 3 sectors (Figure 1): private, non-commercial volunteer groups, the social welfare conference, and self-governing bodies. In recent years, private sectors have begun to receive administrative subsidies as a result of serious financial problems. And although some self-governing bodies operate "Handicab" directly, most self-governing bodies entrust its operation to taxi companies. Although the government and self-governing bodies provide financial aid to private sectors, there is no method for judging volunteer groups in order to determine proper subsidies. The situation is same when a contractor is chosen to provide service. There is also no effective means for monitoring the quality of service of current providers. In order to evaluate the quality of ST service, it is useful to investigate data from the viewpoint of users, such as: important factors regarding service, degree of satisfaction with the service, and differences in the degree of satisfaction between different user groups. There have been few research papers, though, evaluating of the quality of ST service in Japan.

In this paper we will discuss: a) current implementations of door-to-door service in Japan, b) an evaluation of the quality of ST service from the viewpoint of the users, c) an analysis of the cost-effectiveness of ST service.

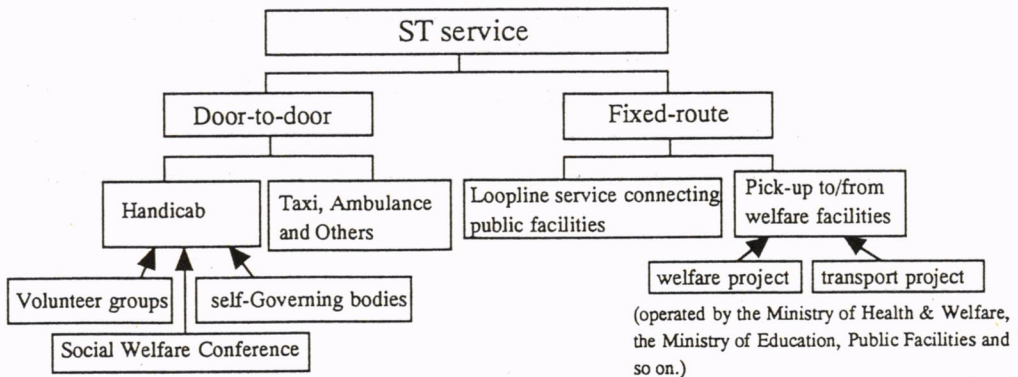


Figure 1 Classification of ST service in Japan

## 2. QUANTITATIVE METHODOLOGY FOR EVALUATING THE QUALITY OF ST SERVICE

### 2.1 PROCEDURE OF EVALUATION

Whether or not a ST service satisfies the needs of mobility-handicapped persons is very much a subjective call. For this reason, psychometric scaling techniques have been proposed as a means for measuring a subject's feeling of satisfaction. To evaluate the quality of ST service in the present study, we use, in part, a method of quantification of subjective aspects of decisions as developed by Miller (1970). He provides a framework for incorporating judgment into a decision process. The steps laid out in the present study are as follows:

- ① Set up a list of evaluation criteria that are complete, mutually exclusive, independent of each other, and of major significance
- ② Establish a hierarchical structure of successively more specific evaluation criteria
- ③ Determine weights indicating the relative importance of each criterion
- ④ Select physical performance measures and determine the level of satisfaction for each lower-level criteria
- ⑤ Establish a scoring function
- ⑥ Develop an index of quality of service

## 2.2 Establishing a List of Evaluation Criteria

In order to make these tasks specific to the development of quality of service indices, the first step was to set up a list of evaluation criteria (aspects) and more specific criteria (attributes) of quality of service. This task was accomplished through a review of the literature concerning quality of service and performance measures in conventional transit, and special transport services. The resultant attributes were further refined through discussions with experts in the special transportation field.

The next step was to establish a hierarchical structure. The attributes were grouped under eight general aspects which make up the quality of service. Each of the aspects and attributes are shown in Figure 2.

## 2.3 Estimating Weights

The third step was to determine weights that reflect the importance of the individual attributes to the relevant aspect and the importance of each aspect to the quality of service. A series of questionnaire surveys were used to estimate the appropriate weights. A questionnaire was sent to the users of door-to-door service ("Handicab") provided by private volunteer groups (19 groups), the social welfare conference (15 groups), and self-governing bodies (10 groups) in the Tokyo metropolitan area. Weights were estimated for 3 operator groups and for individual providers. Since the users of the ST service are elderly and disabled persons,

the survey used semantic differential techniques rather than ranking or scaling techniques in order to reduce the complexity of the questionnaire.

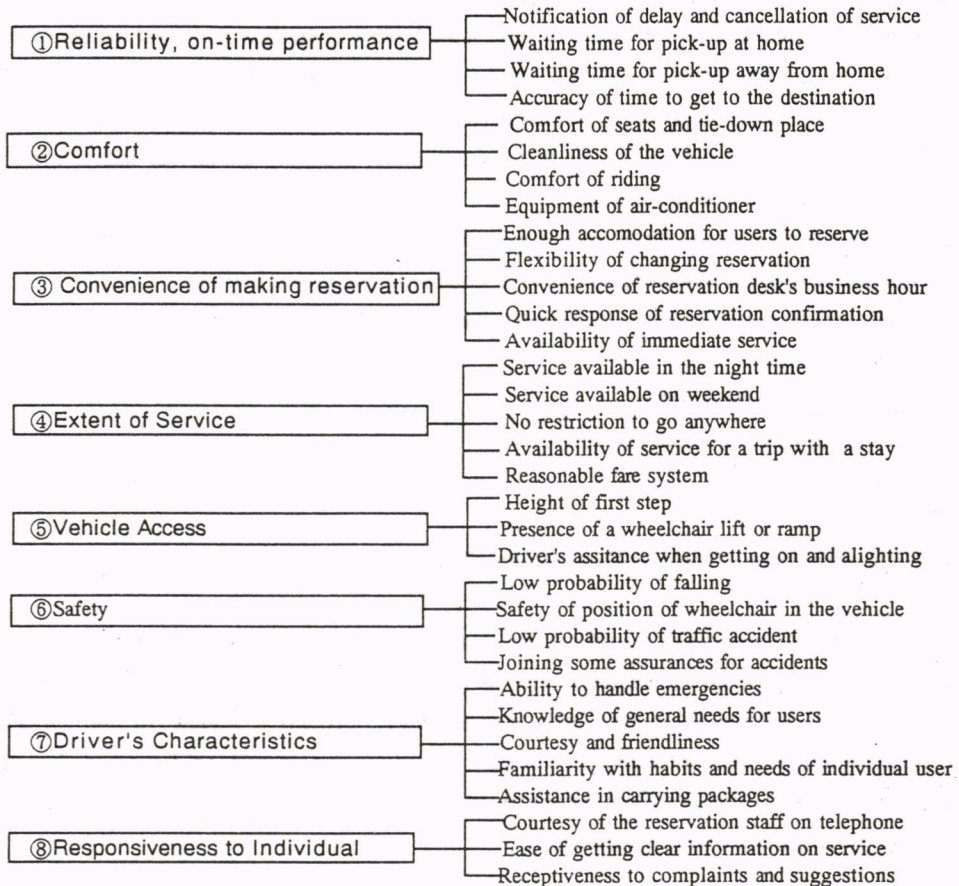


Figure 2 Aspects and attributes of service of quality

## 2.4 Measuring the Level of Satisfaction

The performance of a transportation system is ultimately measured in terms of the level of satisfaction of its clients. In this research, in order to measure the performance of service, a user questionnaire survey was conducted concurrently with the survey for determining weights. Semantic differential techniques were again used as a scaling method.

## 2.5 Establishing Scoring Functions

This step in the development of a methodology to measure the quality of service for

mobility-handicapped persons concerns the development of scoring functions that relate the measure of an attribute to the level of satisfaction for that attribute. The scoring functions were designed so that complete satisfaction equals one and complete lack of satisfaction equals zero. In evaluating ST service, weighted-scores for each attribute were combined to create an index of quality of service score for the provider. This index can be represented as follows:

$$Q_k = \sum_i \sum_j W_j \cdot W_{ij} \cdot S_{ijk}$$

where :

$Q_k$  = Index of quality of service for service provider  $k$

$W_j$  = The relative importance of aspect  $j$  to quality of service

$W_{ij}$  = The relative importance of attribute  $i$  to aspect  $j$

$S_{ijk}$  = score for attribute  $i$ , under aspect  $j$ , for service provider  $k$

The scoring functions were designed so that the  $\sum_i W_{ij}$  for each aspect  $j$  sum to ten, and the  $\sum_j W_j$  also sum to ten. The quality scores are assigned values from zero to one. As a result, index of quality of service can take on values from zero to 100, where 100 represents a level of perfect satisfaction for every attribute.

### 3. CASE STUDY

#### 3.1 Survey of Current Implementations of "Handicab"

To validate the methodology mentioned above, it is necessary to investigate the current implementations of door-to-door service ("Handicab"). For this task, we conducted a series of surveys based on the "Guidebook of providers of Handicab in Tokyo", meetings with the "Tokyo social welfare conference", and the "Tokyo Handicab conference". As a result of the survey, we found that there are three operator groups which provide door-to-door service for the elderly and disabled persons with lift-equipped vehicles. The three operator groups are: ① private, non-commercial volunteer groups, ② the social welfare conference, ③ the welfare bureaus of self-governing bodies.

#### 3.2 Summary of the Questionnaire Survey

##### 3.2.1 Survey procedures

A questionnaire survey was conducted to measure the quality of ST services. Figure 3

shows the procedures used for the survey.

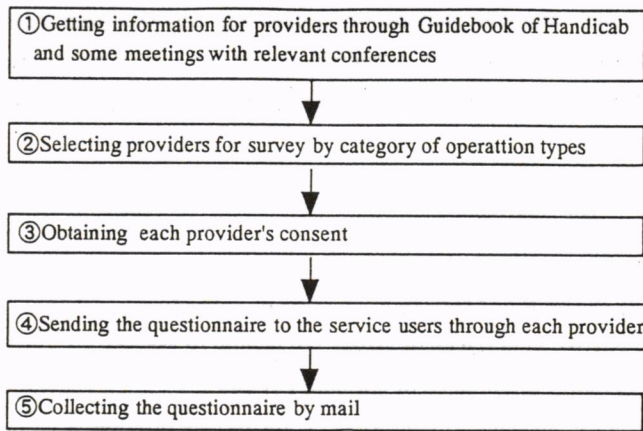


Figure 3 Procedures used for the questionnaire survey

### 3.2.2 Survey method

A questionnaire was sent to the users of 44 (19 from private volunteer groups, 15 from social welfare conferences, 10 from self-governing bodies ) with the consent of each service provider. Handicab services operated in Tokyo metropolitan area of the 117. A mail-back questionnaire was sent to 2100 people through each service provider in October, 1996, and total of 969 usable questionnaires were returned(return rate: 46%).

### 3.2.3 Survey contents

The questionnaire contained questions regarding the personal attributes of the users, the importance of the evaluation criteria, and the level of user satisfaction with the service (Figure 4). They are summarized as follows:

#### 1) Personal attributes of the users

In order to evaluate the quality of service by different user profiles, personal attributes were asked such as sex, age, wheelchair -user or not, frequency of service use, etc.

#### 2) Importance of the evaluation criteria

In this study, quality of service is measured along eight dimensions. These are reliability, comfort, convenience, extent of service, vehicle access, safety, driver characteristics, and responsiveness. Semantic differential techniques were used to determine the relative importance of these aspects on a scale ranging from "least" (1) to "most" (5). The importance of the individual attributes to the relevant aspect was determined by the same method.

3) Level satisfaction with the service

To measure the level of satisfaction for individual attributes, semantic differential techniques were also used as in the case of measuring weights. But in this case, the level of satisfaction was measured on a scale ranging from "least" (1) to "most" (10) in order to obtain a more detailed response from the users.

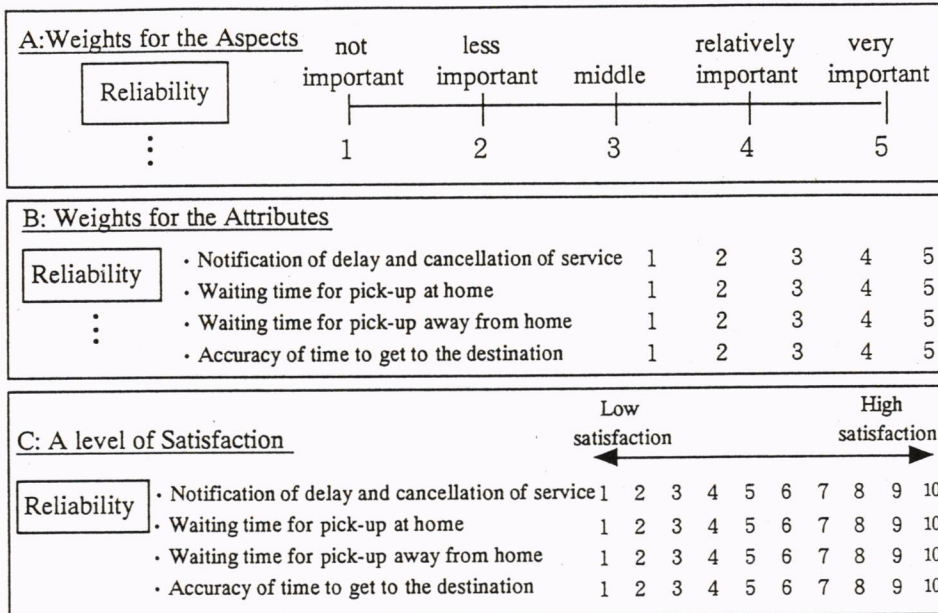


Figure 4 Examples of the questionnaire

3.3 Results of the Evaluation of the Quality of Service

3.3.1 Estimation of weights for the aspects

The results of the estimated weights for the eight aspects are presented in Figure 5. In looking at the average weights for the all service providers, "Convenience of making reservation" and " Safety" rated highest with 1.29, followed by "Reliability" (1.28), "Vehicle access" (1.27), "Driver characteristics" and "Responsiveness to individual" (1.24). At the other end, "Comfort" rated a very low 1.16. With slight differences, the same pattern is seen among all three operator groups.

3.3.2 Measurement of the level of satisfaction and the overall quality of service index

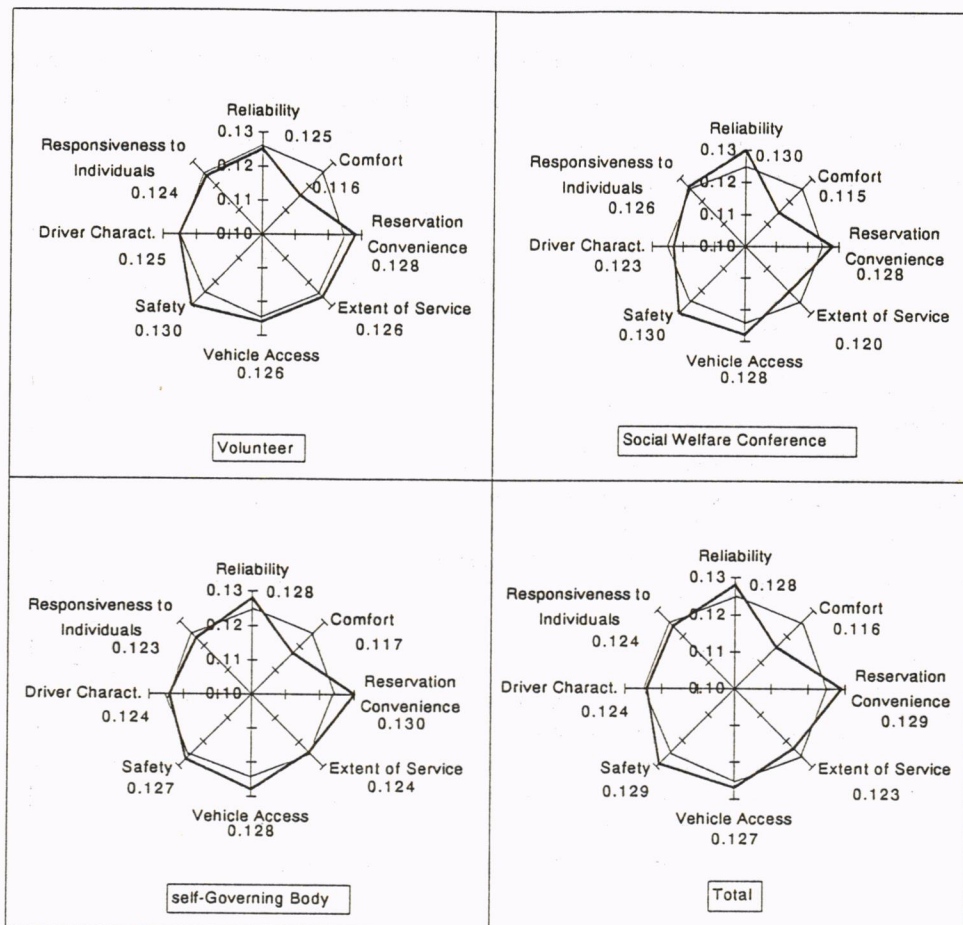


Figure 5 Estimated weights by different operator groups

The level of satisfaction with the quality of service was measured by each of 33 attributes. In order to simplify the results, these can be grouped by eight aspects and scaled from zero to one. As for the results, "Reliability" scored highest with 0.85, followed by "Vehicle access" and "Safety" of 0.84. At the low end, "Extent of service" and "Convenience of making reservation" had scores of only 0.63 and 0.7, respectively.

Looking at the results in more detail, some attributes have particularly high scores, such as "waiting time for pick-up at home" in "Reliability", "presence of a wheelchair lift or ramp" in "Vehicle access", and "low probability of traffic accidents" in "Safety". On the other hand, some attributes have notably low scores, such as "service available in the night time" in "Extent of service", and "availability of immediate service" in "Convenience of making reservation".



The average overall quality of service index for the 44 service providers is 77.5 points out of 100 (Table 1). The scores are distributed from 65.1 to 92.7. The results by different service operator groups are: 79.9 points for private volunteer groups, 77.1 for social welfare conferences, 75.7 for self-governing bodies. These results show that there is little difference in the service quality of three operator groups. Analysis of the distribution of the indices among the three operator groups reveals there are 8 providers with indices "more than 80", 9 with "71~80", and 2 with "less than 70" among the private volunteer groups. Among the social welfare conferences, 13 providers out of 15 scored "71~80". And among the self-governing bodies, there are 3 providers with indices "more than 80", and 6 with "less than 70"(Figure 6).

Table 1 Overall quality of service and level of satisfaction by 3 operator groups

Aspects	Weights (W <sub>i</sub> )	Attributes	Weights (W <sub>ij</sub> )	Volunteer	S.W.C.*	self-G.B.	Total
				Sijk **	Sijk	Sijk	
Reliability and On-Time Performance	1.28	Notification of delay and cancellation of service	2.82	0.79	0.83	0.81	{0.85}
		Waiting time for pick-up at home	2.45	0.85	0.87	0.87	
		Waiting time for pick-up away from home	2.44	0.83	0.86	0.85	
		Accuracy of time to get to the destination	2.5	0.84	0.86	0.86	
Comfort	1.18	Comfort of seats and tie-down place	2.57	0.77	0.78	0.78	{0.80}
		Cleanliness of the vehicle	2.38	0.79	0.79	0.82	
		Comfort of riding	2.52	0.76	0.76	0.76	
		Equipment of air-conditioner	2.54	0.85	0.86	0.86	
Convenience of Making Reservation	1.29	Enough accomodation for users to reserve	2.13	0.77	0.73	0.68	{0.70}
		Flexibility of changing reservation	1.98	0.77	0.70	0.70	
		Convenience of reservation desk's business hour	1.94	0.76	0.72	0.67	
		Quick response of reservation confirmation	2.01	0.78	0.83	0.81	
Extent of Service	1.23	Availability of immediate service	1.95	0.80	0.48	0.50	{0.63}
		Service available in the night time	1.97	0.81	0.38	0.49	
		Service available on weekend	2.05	0.78	0.54	0.7	
		No restriction to go anywhere	2.05	0.75	0.55	0.67	
		Reasonable fare system	2.12	0.76	0.80	0.71	
Vehicle Access	1.27	Height of first step	3.16	0.75	0.77	0.76	{0.84}
		Presence of a wheelchair lift or ramp	3.44	0.85	0.90	0.89	
		Driver's assistance when getting on and alighting	3.39	0.86	0.90	0.87	
Safety	1.29	Low probability of falling	2.51	0.84	0.86	0.86	{0.84}
		Safety of position of wheelchair in the vehicle	2.52	0.81	0.86	0.86	
		Low probability of traffic accident	2.57	0.88	0.89	0.88	
		Joining some assurances for accidents	2.4	0.84	0.75	0.77	
Driver Characteristics	1.24	Ability to handle emergencies	2.11	0.76	0.71	0.71	{0.78}
		Knowledge of general needs for users	2.06	0.80	0.78	0.77	
		Courtesy and friendliness	2.08	0.86	0.87	0.85	
		Familiarity with habits and needs of individual user	1.85	0.77	0.74	0.73	
		Assistance in carrying packages	1.9	0.81	0.81	0.75	
Responsiveness to Individual	1.24	Courtesy of the reservation staff on telephone	3.41	0.82	0.86	0.79	{0.74}
		Ease of getting clear information on service	3.28	0.74	0.71	0.84	
		Receptiveness to complaints and suggestions	3.31	0.74	0.72	0.83	
Serviceindex				79.9	77.1	75.7	77.5

\*S.W.C.: Social Welfare Conference

\*\*Sijk: level of satisfaction for attribute *i*, under aspect *j*, for service provider *k*

{ } : level of satisfaction of 3 operator groups for aspect *j*

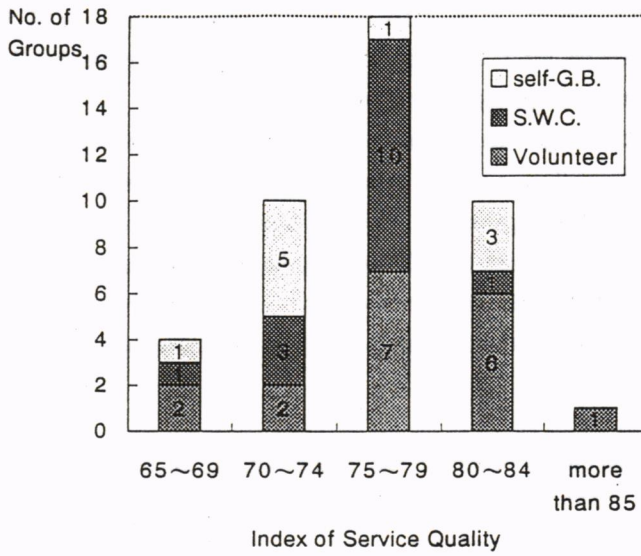


Figure 6 No. of providers by index of service quality

3.3.3 Evaluation of quality of service by personal attributes

In order to evaluate the quality of service by different user profiles, four categories were formed "age" and "use of wheelchair". As shown in Table 2, the "more than 65 with use of wheelchair" category gave the highest evaluation (79.7 points), on the other hand, the "less than 64 without use of wheelchair" category scored the lowest (74.3). From this analysis, it

Table 2 Index of quality of service by personal attributes

	Volunteer	SWC	self-G.B.	Total
I : more than 65 with use of wheelchair	84.5	79.4	75.3	79.7
II : more than 65 without use of wheelchair	79.8	74.9	—*	77.3
III : less than 64 with use of wheelchair	76.9	74.6	75.0	75.5
IV : less than 64 without use of wheelchair	79.8	68.9	—*	74.3
under no classification of personal attributes				
	Volunteer	SWC	self-G.B.	Total
mean	79.9	77.1	75.7	77.5
range	65.12-92.7	66.97-80.06	69.72-84.35	65.12-92.7
standard dev.	5.99	3.67	5.2	5.24

\* uncountable score because of small No. of samples

would seem that the door-to-door service is used mainly by the elderly over 65 and severely disabled persons who use wheelchairs.

### 3.3.4 Evaluation of the quality of service by relating level satisfaction and weights

It is possible to check the strengths and weaknesses of a service by comparing the estimated weights and satisfaction levels for the aspects simultaneously. The results of this evaluation could be used effectively by the providers in order to improve their service systems. Figure 7 illustrates the results of this evaluation. The results show that the current strengths of service providers are aspects such as "Reliability" (①), "Safety" (⑥), and "Vehicle access" (⑤) which have high weights and high levels of satisfaction. On the other hand, aspects such as "Convenience of making reservation" (③) and "Extent of service" (④) are revealed as weaknesses because their satisfaction levels are low while their weights are high. As shown in Figure 7, the same tendency can be seen among all three operator groups. This analysis was conducted using data from the 44 individual providers in this study.

## 3.4 Cost-Effectiveness analysis

Cost-effectiveness of door-to-door service is measured by using "cost per trip" and "cost per km" in this study. Table 3 shows "cost per trip" based on the annual operating cost (excluding vehicle purchase cost) and the annual total number of trips. As shown in Table 3, the range of cost per trip by individual provider is relatively wide. Looking at the average cost per trip for the three operator groups, the social welfare conferences have the lowest cost with ¥6,108/trip, while the private volunteer groups and self-governing bodies have much higher cost with ¥9,106/trip and ¥9,947/trip, respectively. Table 4 indicates "cost per km" calculated from the annual operating costs and the annual vehicle mileage in kilometers. There is a wide range in the cost per km for individual providers, similar to that seen in the "cost per trip" analysis. Private volunteer groups, have the highest cost with ¥824/km, followed by self-governing bodies with ¥724/km, and social welfare conferences with ¥307/km.

From the analyses of "cost per trip" and "cost per km", it is evident that there are large differences between individual providers and different operator groups. But, the differences could be caused by various operational characteristics, such as the amounts of coordination costs, the level of labor costs, types of drivers used, and whether or not there are rental and parking lot costs. For this reason, it is necessary to analyze cost-effectiveness by subdividing the operational characteristics of service providers in future studies.

No.	Aspects	Vol.Weight	Vol.Sat.	SWC Weight	SWC Sat.	SGB Weight	SGB Sat.	Total Weight	Total Sat.
①	Reliability	1.25	0.83	1.30	0.85	1.28	0.86	1.28	0.85
②	Comfort	1.16	0.79	1.15	0.80	1.17	0.81	1.16	0.80
③	Resv.Convenience	1.28	0.74	1.28	0.69	1.30	0.67	1.29	0.70
④	Extent of Service	1.26	0.71	1.20	0.55	1.24	0.62	1.23	0.63
⑤	Vehicle Access	1.26	0.82	1.28	0.86	1.28	0.84	1.27	0.84
⑥	Safety	1.30	0.84	1.30	0.84	1.27	0.84	1.29	0.84
⑦	Driver Character	1.25	0.80	1.23	0.78	1.24	0.76	1.24	0.78
⑧	Resp.to Individual	1.24	0.76	1.26	0.76	1.23	0.68	1.24	0.74

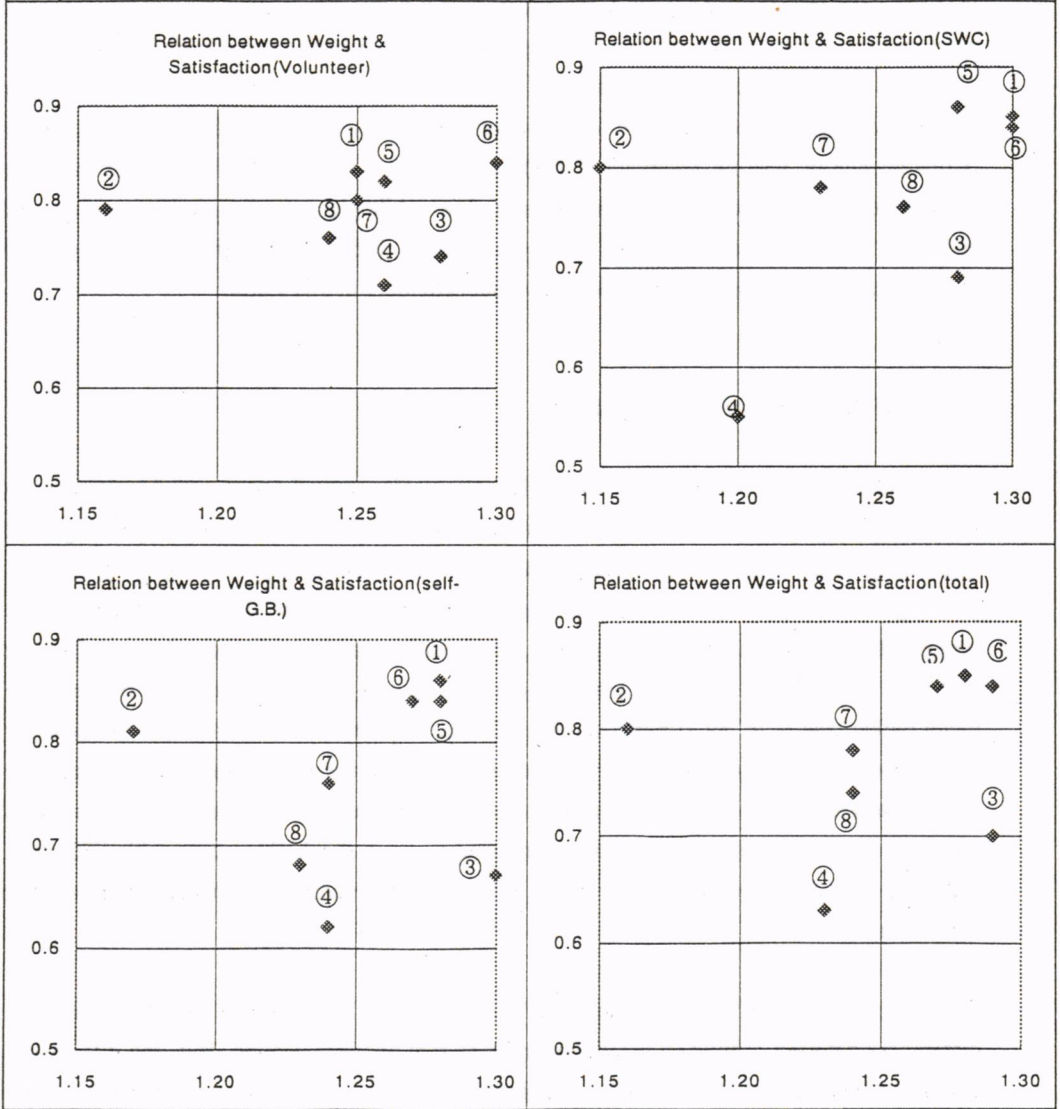


Figure 7 Relation between weights and satisfaction degree

Table 3 cost per trip (unit:Yen)

		private volunteer	S.W.C	self-G.B.
average*		9,106	6,108	9,947
range	max.	18,973	12,447	19,792
	mim.	2,174	2,380	2,705
standard deviation		4,546	2,858	4,496

\*the average cost of 22 of private volunteer groups, 13 of social welfare conference, 18 of self-governing body.

Table 4 cost per km (unit:Yen)

		private volunteer	S.W.C	self-G.B.
average*		824	307	724
range	max.	3,487	764	1,357
	mim.	193	134	339
standard deviation		783	189	297

\*the average cost of 19 of private volunteer groups, 11 of social welfare conference, 12 of self-governing body.

#### 4. SUMMARY AND CONCLUSION

The findings of the present research are summarized as follows:

- ① A quantitative methodology to evaluate the quality of ST service was proposed. In this methodology, quality of service was measured along 8 dimensions. These are reliability, comfort, convenience of making reservation, extent of service, vehicle access, safety, driver characteristics, and responsiveness.
- ② According to the results for estimating weights, "Convenience of making reservation" and "Safety" (1.29), "Reliability" (1.28) showed the highest weights, while "Comfort" (1.16) showed the lowest weight.
- ③ As for the results in measuring the level of satisfaction, "Reliability" showed the highest score with 0.85, followed by "Vehicle access" and "Safety" with 0.84. At the low end are "Extent of service" and "Convenience of making reservation" with 0.63 and 0.7, respectively.
- ④ The average overall index for service quality for the 44 service providers was 77.5 points

out of 100. The scores ranged from 65.1 to 92.7. But the average score for the three operator groups were similar (79.9~75.7).

⑤ In the evaluation by personal attributes, the "more than 65 with use of wheelchair" category evaluated highest (79.7 points), while the "less than 64 without use of wheelchair" category evaluated lowest (74.3).

⑥ In comparing the estimated weights and the satisfaction levels for the various aspects, "Convenience of making reservation" and "Extent of service" were revealed as weaknesses because their satisfaction levels were low while their weights were high.

⑦ From the analyses of "cost per trip" and "cost per km", it is evident that there are large differences between individual providers and different operator groups.

The results of this evaluation of service quality can be used by the government or self-governing bodies when they choose contractors, or when they provide financial aid to private sectors. They can also be used as a method for judging the performance of each provider, and comparing the quality of different services. Finally, this study provides useful data which can be used by providers in order to improve their services.

## REFERENCES

Yupo Chan (1987) Measuring the efficiency, effectiveness, and satisfaction of transportation services for elderly and handicapped persons. *Journal of Special Transportation Planning and Practice* Vol. 2, 279-301.

Anthony, M.P. and Clair, E.M. (1989) Evaluating the quality provided by privated sector special service contractors. *5TH International Conferences on Mobility and Transport for Elderly and Disabled Persons*, Stockholm, Sweden, 21-24, May 1989.

Miller, J.R. (1970) *Professional Decision-Making : A Procedure for Evaluating Complex Alternatives*. Praeger Publishers, New York.