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# PLANNING OF FLEXIBLE TRANSPORT SERVICES FOR RURAL AREA CONSIDERING OPERATION COST

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This paper focuses on the potential role of Flexible Transport Service (FTS) in low and dispersed demand area. In Japan, after the deregulation in 2002, some mass transit companies left from bus services in local areas. This causes problems to some older people and disabled people with difficulties on traveling in rural areas. To meet these needs, the term demand responsive transit (DRT) has been increasingly applied because it can provide passengers with alternative options on route, schedule, at a lower operating cost compared to the infrequent fixed route local public bus services. DRT needs, however, a quite large subsidy for the low density area and is not so popular for elderly people because of it's level of service. On the other hand, Taxi Subsidy Scheme (TSS) that subsidizes on the taxi fare is being carried out widely by local authorities in Japan to support the special groups' transport needs. In this research, we aimed to examine the role of taxi subsidy system from the relation with on demand ride-sharing taxi in depopulated area.

***Key Words :*** *flexible transport services, rural areas, taxi fare subsidy, internet survey*

## 1. INTRODUCTION

A flexible public transportation service is a general term which describes a range of arrangements that are typically used in local public transportation. FTS is defined as a transport service which has some flexible characteristics on route, vehicle, schedule, and passenger and payment system[1)]. In the public transportation service, this competes with the traditional type of service which comes along with a fixed timetable, fixed route, and fare, and scheduled drivers with vehicles on a regular basis. FTS system usually use Travel Dispatch Centers (TDCs) to deal with the booking and reservation process[2)]. This device has the ability to arrange passengers to vehicles and schedule the time.

When we look at the previous time of FTS[3)], there were door-to-door Dial-a-Ride services (sometimes called as Special Transport Services - STS) in the past. This service was provided for restricted groups (usually the disabled and elderly). Customers must do the telephone booking some days in advance before they plan to travel so that the manager would arrange the service manually the day before the trip.

Recently, Flexible Transport Services have been playing vital rule in several European cities as well[3)], areas and regions with advanced interest and benefits as a creative supplementary solution to the traditional, fixed passenger transport service. Especially, these types of flexible transport services become an optimal method for low density population regions where demand service hour is low, in addition to this, target users are also disassembled among the special groups such as elderly, disabled people and students and tourists.

Implementing of FTS in rural areas may be the optimal solution for current state of rural areas transportation, but there are still some challenges to be conquered[2)]. Compared with fixed, conventional services, low demand rate also seems to an obstacle to cause insufficient service provider in dispersed rural areas. Another factor that challenges the present situation of transportation for these regions, is that local authorities often have funding barriers. And that would be a reason for many services in rural areas or areas of low demand have been stopped from service since the level of subsidy requirement is too high to satisfy within the set of competing requirements.

Now, the worldwide nation's population is entering the aging society. The dramatic change on the population will cause new challenges for the provision of transportation services. In low density, rural areas, infrequent fixed route public transportation is not able to meet the need of special groups such as elderly who don't have driving license or fear to drive and disabled people. FTS plays an important role for improving the social inclusion where demand is low and often spread large area.

In Japan, after the deregulation in 2002, some mass transit companies left from bus services in local areas. This causes problems to some older people and disabled people with difficulties on traveling in rural areas[4]. Demand responsive transit (DRT) are being introduced in some rural areas of Japan as being one of the solutions among FTS. DRT needs, however, a quite large subsidy for the low density area and is not so popular for eldrly people because of it's level of service. To meet these needs, Demmand Share-Ride Taxi system is also introduced which uses normal taxi vehicle and TDCs to match demand of people.

On the other hand, Taxi Subsidy Scheme (TSS) that subsidizes on the taxi fare is being carried out widely by local authorities in Japan to support the special groups' transport needs. TSS supports the transport costs for limited groups who have difficulties on utilizing public transport service because of their physical weakness. This types of service affords community members with general social inclusion and participation of social activities[5].

According to the statement of Ishio et al.[6], the taxi subsidy scheme which is currently runned in japan is also classified into the following three types.

1. Elderly type — this type refers to the condition of people who is at the age of 70 or over.
2. Welfare type — this type refers to the condition of people with disability regardless of age.
3. Integrated type — this type refers to a type that integrates both elderly and welfare type.

The taxi fare subsidy system was developed under the charge of welfare department of the municipality. To provide limited number of people who experience profound difficulties using other modes of public passenger transport, a fixed number of tickets per year are provided which can use as a part of payment when they take taxi. In depopulated areas, taxi fare subsidy system is mainly used for outpatient visits and shopping etc. However, there are restrictions on the number of times of use per year, and it cannot deal with the high frequency movement of demand.

However, the number of these types of rural areas where the public transportation is not efficient, in addition the efficiency of on-demand ride sharing is also low is increasing, which shows the pressure need for satisfying the sustainable mobility of community.

On demand ride sharing taxi is a mobility service that combines the features of both taxi service and local bus service like providing door-to-door service, sharing together with other passengers at fixed fare. In the following, we address it DRST as abbreviations.

Therefore, this study aims to clarify the characteristics of taxi subsidy system based on its potential role for going out, and also to examine the role of taxi subsidy system from the relationship with on-demand ride sharing taxi in low density areas.

Specifically, in order to show the actual situation for implementation of taxi subsidy system in depopulated areas, we compare the scope of the target person and the level of subsidies with the taxi subsidy schemes.

## 2. EXISTING RESEARCH AND PURPOSE OF THIS STUDY

According to the statement done by Nelson et al.[3], Finland and Belgium adopted DRT into their mainstream public transport system for its citizens who are over 65. From these experiences, the both countries found that it is very important for government to consider about the quality of life of its elderly citizens and the ability to live independently. Also, it is not difficult to find that, with the help of latest technologies like Travel Dispatch Centers (TDCs), Automated Vehicle Location (ALV), FTS service is able to satisfy the large number of requests of people and cars.

While such provision is common in economically less developed countries where institutional and/or land use factors prevent conventional buses from meeting demand, in the UK and Western Europe as a whole such flexible transport options have largely been focused on meeting the needs of mobility impaired passengers[7].

There are particular market niches, which cannot be served without the ability to provide a flexible transport solution. In particular, some user groups require door-to-door DRT provision to access the services that they require. Overall, expansion of DRT provision is an essential aspect of improving accessibility in Scotland[8].

In Japan, although there are many existing studies on demand ride sharing taxis and community buses, but there are few studies on taxi subsidy schemes from the viewpoints of rural transport planning because this schemes were developed under the charge of welfare department of the municipality as mentioned.

A research by Hayakawa[9] in 2004 compared FTS systems and showed that demand type taxi is the mainstream for region with a population of over 6,000. But for population under 6000, and additional situation if there is no taxi operator, a kind of private car service without taxi licence, called "jikayo_yusho" in Japanese provided by local residents is welcomed. However, if taxi operators exist, they consider the implementation of taxi service with subsidy for users. For example, Bicchu town of Okayama prefecture (population approximately 2000) introduced paid transportation by private cars as "welfare transfer service", and Nega village of Nagano prefecture (population approximately 900) adopts the demand ride sharing taxi service.

According to other Hayakawa's[10] research, Tatebayashi city of Gunma prefecture (population approximately 78.000) and Omachi city of Nagano prefecture (population 29.000) also introduced taxi subsidy scheme to the elderly with the elimination of the bus service. In these two cities, elderly people were supported by distributing taxi tickets, but the pressure on municipality and users increased. This revealed a fact that bus service is more efficient than taxi subsidy system, which caused the restart of bus service in these regions. However, Hayakawa said that taxi subsidy system makes a certain sense because some elderly people has the difficulty to access to the bus stop.

Meanwhile, according to another research done by Moriyama[11], demand ride-sharing taxi seems not to be economical because of cost for the reservation operation. In fact, sometimes it is necessary for driver to wait for customers, which is costly. In addition to this, reservation problems also form barriers for older people. In this way, proper introduction, especially the policies including taxi utilization would be vital in considering the local condition in depopulated areas.

Ishio et al.[6] evaluated the characteristics of taxi subsidy systems introduced in 57 local authorities, the expenditure per user annually is high at 20,000 yen on average and 40,000 yen at the maximum, but in the elderly type it is as small as 7,000 yen on average, 19,000 yen at maximum, even in the case of integrated type The average is 9,000 yen. The necessity of covering the target people increases the requirements for the content of the service.

Ishio et al.[6] also conducted an online survey of 1000 samples as well to evaluate taxi subsidy systsme from the viewpoints of taxpayer's side. In the questionnaire about people's opinions on this service, approximately 30 to 40% said "basically good", 8% or less said "no need". People prefers taxi fare subsidy scheme for elderly people with less amount of payment by government, they also agree to secure enough mobility of persons in difficult situation.

From these results, they proposed that taxi subsidy system would be more optimal for government than on demand type service according to the operation cost in depopulated areas. It is not still clear, however, what the conditions of characteristics of rural areas is need for the adopt of taxi subsidy system by local government.

Considering the above previous studies, this study aims to examine the role of taxi subsidy system from the relation with on demand ride- sharing taxi from satisfying the demand of special groups in rural, dispersed population areas.

## 3. THE COST ANALYSIS OF TAXI SUBSIDY SYSTEM AND DEMAND RIDE SHARING SERVICE

### (1) Outline of operating cost for simulation model

In this study, a simulation model is developed to estimate the operating cost of taxi subsidy system and on demand ride sharing taxi service, which consider the sharing ratio according to population density. In general, for the evaluation of mobility services, the satisfaction level and payment of users, and management by supplier and operation cost by local government are to be considered. In this research, the authors focus on the operation cost by government considering as funding barrier of FTS.

### (2) Creating the targeted model area

Sana-gouchi village in Tokushima Prefecture is chosen as a targeted model area, spreading virtually from center to suburbs. The image of village area is shown in **Fig.1**. The village is consist of 16 areas of two grids of 1 km square, the population density decreases as going from the center to the outside. According to the actual situation of Sana-gouchi village in Tokushima Prefecture, we assumed the population of each areas as model A, and in order to evaluate the effect of demand size, we assumed population model B which is created by multiplied A by 5.0. The population of each model by area is shown in **Table 1**. In this study, mobility support service is provided for the trips of residents moving from each area to the center.

### (3) Assumption for targeted people

The population ratios of four target groups for the

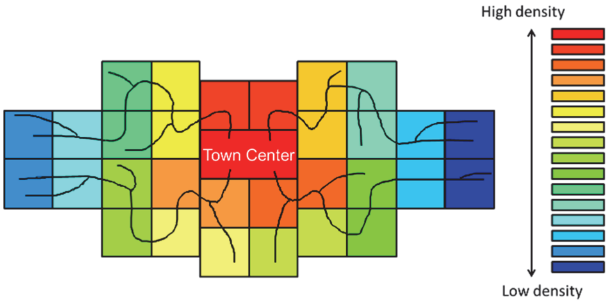


**Fig.1** Model region for simulation analysis.

**Table 1** Assumed population of model village.

| Aera | Ratio of population | Population | |
|---|---|---|---|
| | | Model A | Model B |
| 1 | 0.11% | 3 | 15 |
| 2 | 0.32% | 9 | 45 |
| 3 | 0.54% | 15 | 75 |
| 4 | 0.87% | 24 | 120 |
| 5 | 1.16% | 32 | 160 |
| 6 | 1.62% | 45 | 225 |
| 7 | 1.84% | 51 | 255 |
| 8 | 2.38% | 66 | 330 |
| 9 | 2.74% | 76 | 380 |
| 10 | 4.15% | 115 | 575 |
| 11 | 6.21% | 172 | 860 |
| 12 | 8.84% | 245 | 1225 |
| 13 | 11.66% | 323 | 1615 |
| 14 | 16.17% | 448 | 2240 |
| 15 | 18.41% | 510 | 2550 |
| 16 | 22.96% | 636 | 3180 |
| Total | 100.00% | 2770 | 13850 |

**Table 2** Estimated ratio of target group of FTS.

| case | target group | estimated population ratio | source |
|---|---|---|---|
| T1 | Disable | 4% | MHLW 2012 |
| T2 | 75 years old and older non driver licence holder | 9% | MIAC Statiscs Bureau 2012 |
| T3 | 65 years old and older non driver licence holder | 14% | |
| T4 | 20 years old and older non driver licence holder | 21% | NPA 2012 |

Disabled : people who have issued Physical disability certificate by the Act on Welfare of Physically Disabled Persons

| Area | Responsibility Case | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 1 | – | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 2 | – | – | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 3 | – | – | – | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 4 | – | – | – | – | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 5 | – | – | – | – | – | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 6 | – | – | – | – | – | – | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 7 | – | – | – | – | – | – | – | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 8 | – | – | – | – | – | – | – | – | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 9 | – | – | – | – | – | – | – | – | – | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 10 | – | – | – | – | – | – | – | – | – | – | ○ | ○ | ○ | ○ | ○ | ○ |
| 11 | – | – | – | – | – | – | – | – | – | – | – | ○ | ○ | ○ | ○ | ○ |
| 12 | – | – | – | – | – | – | – | – | – | – | – | – | ○ | ○ | ○ | ○ |
| 13 | – | – | – | – | – | – | – | – | – | – | – | – | – | ○ | ○ | ○ |
| 14 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ○ | ○ |
| 15 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ○ |

○ : Responsible by TSS — : by DRST

**Fig. 2** The distribution of mobility services by area.

mobility service are estimated, shown in Table 2. In these cases, it excludes students commuting for school. On demand ride sharing taxi targeted people whose age is over 20 and without driving license covers about 21% as marked T4. T4 is shown to make it clear for the explanation of case of expanding the targets of TSS.

In this simulation, we only adopted T1, T2, and T3 for simulation study case in order to focus on the planning for the mobility of elderly people. The subjects of taxi subsidy system were such persons like disabled people (the one who have issued Physical disability certificate by the Act on Welfare of Physically Disabled Persons), "old" elderly (over 75 years), and "young" elderly (aged 65-75 years). They are marked T1, T2, T3 in the **Table 2**, and the population ratios of these subjects are estimated to be 4%, 9% and 14% respectively.

### (4) Case setting for service sharing by area

Regarding the target ratio of on-demand ride sharing taxi and taxi subsidy system, the scope of each subject was determined by the area described above.

However, the residential area of 16, the central area supported by taxi service is excluded. The distribution of mobility services by area was set as shown in **Fig.2**.

In Case 1, on demand ride- sharing taxi service supports all areas except the central area 16. In Case 2, supporting area 1 with a taxi subsidy system and the rest of the area is supported by on demand ride-sharing taxi. In Case 3, the scope of the taxi subsidy system is expanding. In Case 15, demand ride-sharing taxi only runs in the central area, the remaining areas are supported by taxi subsidy system. And Case 16, supporting all areas with taxi subsidy system except the central area.

### (5) Assumption for required travel distance of demand ride-sharing taxi

In order to support the mobility of local residents in the area by demand ride-sharing taxi, the distance of necessary traveling route was estimated. Here, we adopted the level of service for public transport that is over 70% of the households in the area were provided access to the DRST within 200m operation route considering the catchment area for elderly people.

For the estimation, 20 districts with different density of buildings in Tokushima prefecture were chosen randomly, an operating route satisfying the above conditions was created, and the distance was measured. As shown in **Fig.3**, when the density of the building is low, the necessary route length varies from short to long, but when the density of buildings becomes high, the length seems to be close to the maximum route length. However, the average length of necessary route extension in 1 km square mesh does not vary to the density of buildings as shown in **Fig.4**, so we adopted the total average value of 1.84 km for 1 km square as the necessary route length of DRST.

**(6) Taxi auxiliary ticket utilization rate**

When setting the simulation model, it is not realistic that everyone uses the maximum amount of subsidies. For that reason, by using the differences between (1) average value of usage rate for elderly type (ratio of used number to number of delivery) and (2) the average value of "Annual subsidy amount in case of using the maximum possible amount" and the average value of "municipal expenditure per targeted person" in the elderly taxi subsidy system, it is known that there were two patterns of usage rate of taxi subsidy system.

Based on the Ishio et al.'s previous survey[6] of the existing taxi subsidy system, the mean value of the usage rate of the number of tickets (the ratio of the number of used sheets to the number of delivery sheets) is 48%. On the other hand, the amount of subsidy at the maximum use of time and the mean value of usage rate subsidized by municipal government was only 9%. The difference of these values means that people who have taxi tickets use taxi at lower fare than maximum subsidy fare. From these results, in the taxi subsidy system, the utilization rate out of 48 annual subsidiary times was assumed in two cases of 48% and 9%.

**(7) The utilization rate of demand ride-sharing taxi**

For on demand ride sharing model, the unit price per km was set at 220 yen / km from the reference of value of welfare paid transportation. In addition, from the community bus assessment index by Hyogo prefecture12) of March 2008 listed in the appendix, the relationship between the usage rate and operation frequency is calculated from the utilization rate of number of service of lowest line operated per day compared to the actual number of service operated per day (those whose usage rate is very close to 0% are excluded). As a result, the utilization rate was 0.625%, and the daily frequency was 3.75. However, this usage rate indicates the number of users for the population along the service route. Therefore, in this study, since the ratio of non-driving license holders who over 20 years old is 21% shown in **Table 2**, and

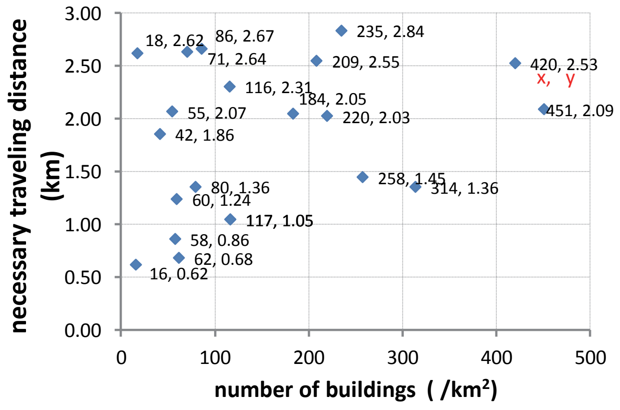


**Fig.3** Relationship between required travel distance per area and the number of buildings.

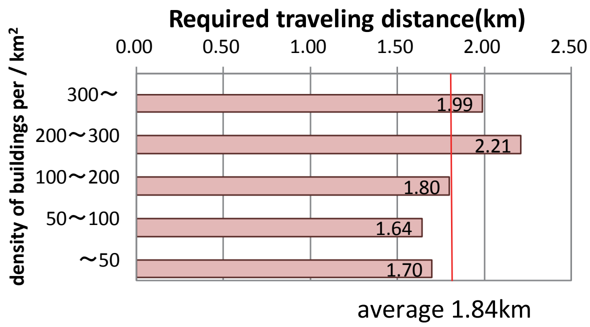


**Fig.4** The required travel distance per area.

the utilization rate is multiplied by 5 and about 3% is used in this study. As for the service frequency, it is assumed that four times in a day as well as twice a week is considered as the lowest line, and 384 times annually.

**(8) Estimation for operation cost for taxi subsidy system**

The amount of grant for taxi subsidy system was set to 3 patterns of 60 yen, 100 yen, and 140 yen per km. This means that the unit price per km of taxi is 200 yen, supporting 30%, 50%, 70% of the amount, and the remaining amount is supposed to be paid by user. As for the travel distance, it was set to 1.84 km which is the same as the required travel distance of the on demand-ride sharing taxi. The number of subsidies is, once a week, 48 times a year.

The estimation formula of the operation cost by local government is as follows (1).

$$\sum_i X_i = dt_i \times sp \times nt \times ur \times pt_i \qquad (1)$$

Here

$X_i$: annual operating cost of TSS for area i ( Japanese yen)

$dt_i$: Service distance from area i (distance to the center × 2)

$sp$: Subsidy per km (yen / km) — 60, 100, 140 yen

$nt$: Annual distribution number of taxi tickets — 48
$ur$: Utilization rate (%) — 9%, 48%
$pt_i$: Number of targeted people in area i (people)

### (9) Estimated operating costs for demand ride-sharing taxi

The unit price for on demand ride-sharing taxi was estimated at 220 yen / km from previous study [13]. It was supposed that the number of service is 4 times a day, twice a week, 384 times a year as a minimum service level that users can see. The fare paid by the user was set to three patterns, one ride 100 yen, 300 yen, 500 yen, which are seen commonly.

The estimation model of the operation cost by local government is as follows (2).

$$\sum_i y_i = ds_i \times cs \times ns - fs \times us \times ps_i \quad (2)$$

Here
$y_i$: Demand ride sharing taxi operation cost to area i (yen)
$s_i$ : Service distance from area i (distance to the center×2)
$cs$: Travel expenses per km — 220 yen / km
$ns$ : Annual number of operations — 384 times / year
$fs$: Demand ride taxi fare —100, 200, 300 yen / times
$us$: Utilization rate of demand ride sharing taxi — 3%
$ps_i$: Targeted population for demand ride sharing taxi for area i

### (10) An example of estimation

As an example, we show the simulation results of the target group case T2 when the supplementary amount of the taxi subsidy system is 60 yen and the usage rate is 9% and the fare of the demand-coupled taxi is 500 yen in the population model B. The results are shown in the **Fig.5**. This figure shows the cost of DRST (violet line) , TSS (green line) separately, the total cost of DRST and TSS (orange line), and the ratio of service area to whole village (red line), according to the percentage of targeted people by DRST for the responsibility cases formed as **Fig.2**. The red point on the orange line indicates the lowest total cost of both DRST and TSS for this case. This optimal operation shows that DRST covers about 91.61% of targeted population with service, however, the service area of DRST is only 56%.

### (11) Simulation results

In the simulation performed for each patterns, the lowest case would be the optimal ratio among the total amount of each case for both taxi subsidy system and demand ride-sharing taxi.

**Table 3** summarizes the simulation results of each pattern performed this time. This table shows, for example, that it is optimal for operation cost to use TSS

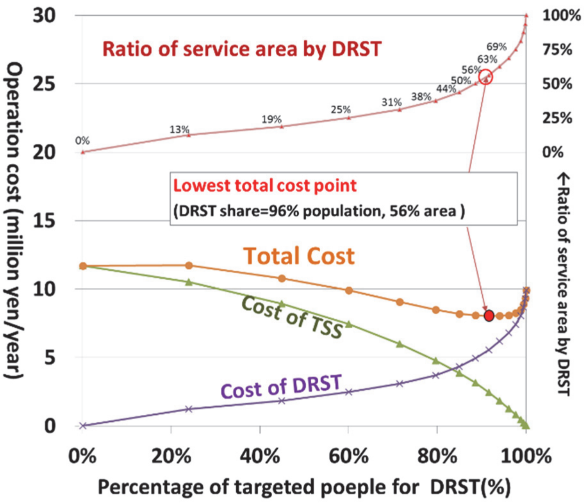


**Fig.5** Total annual operating cost for the proportion of target users in DRST.

**Table 3** Simulation results.

| Optimal Resposibility Patern by DRST and TSS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Utilization ratio of TSS | TSS target group case | Fare for DRST | Model A | | | Model B | | |
| | | | Taxi subsidy system | | | | | |
| | | | 60 yen/km | 100 yen/km | 140 yen/km | 60 yen/km | 100 yen/km | 140 yen/km |
| 9% | T1 | 200～500 yen/ride | | DRST=0% TSS=100% | | | | DRST= 80～96% |
| | T2 | | | | | | DRST= 96～98% | |
| | T3 | | | | DRST=80～96% | | | |
| 48% | T1 | 200～500 yen/ride | | | | | | |
| | T2 | | DRST= 96～98% | | | DRST=98～100% | | |
| | T3 | | | | | | | |

for 100% in population in the conditions of blue boxes, but to use DRST for more use than 98% in population in the conditions of red boxes.

From **Table 3**, the factors which influence the demand operation service ratio are the usage rate of taxi subsidy system, the population of targeted people, and the amount of grant and the ratio of targeted subjects of taxi subsidy system.

Among them, it was found that the utilization rate of the taxi subsidy system and the population of the targeted people have a particularly great influence on the demand operation service sharing ratio. On the contrary, there is no change finding with the situation in which the fare is at 200 yen / times, 300 yen / times, 500 yen / times. Therefore, these results shows that a factor of fare for a demand ride sharing taxi have a little effect on the demand operation service sharing rate.

Also, in this simulation, the scope of the targeted people of the demand ride-sharing taxi was 80% or more when 0% was excluded. As you can see from the table 3, two patterns of utilization rate of TSS 9% and 48% is given, and also the model area is separated into A and B. For the depopulated area like model A, it is better to support the area with taxi subsidy system, in that case the utilization rate of taxi subsidy is 9%, achieving the operation cost in low level. On the other hand, with 48% utilization rate of taxi subsidy, on demand ride-sharing taxi should cover the more than 80% of targeted people. For model area B, with the increasing number of targeted people, it is better to support more than 80% of targeted people with DRST and supporting the remaining people with taxi subsidy system, in this way it can be achieved at lowest cost.

## 4. CONCLUSION

From the simulation results, it can be found that there are 4 reasons that affect the ratio of sharing responsibility by DRST, they are the utilization rate of taxi subsidy system, population of targeted people, amount of grant and the target ratio of taxi subsidy system. Among them, the utilization rate of taxi subsidy system and population of targeted people have a big impact on the ratio of responsibility by DRST. On the contrary, the different level of fare of DRST has no any impact on the ratio of responsibility by DRST.

From the operation cost simulation, we learned that the utilization ratio of TSS has a great influence on the sharing ratio of DRST. There are two patterns of utilization ratio of taxi subsidy system, 9% and 48%. With 9% of ratio, the operation cost in a lowest level is achieved by two patterns. For low density area like model A, it is better to cover all area with taxi subsidy scheme. For areas like model B; five times of population of Model A, to provide more than 80% targeted people with DRST, and cover the remaining part with TSS is better.

Regarding to the policy for Sanagouchi Village as the simulation population model A, it is clear that taxi subsidy scheme has advantage of operation cost for most of utilization assumption cases.

The examination process proposed in this study could be applied to the planning of the operation cost of flexible transport system for depopulated areas in Japan, and it would contribute the creation of discussion on the joint policy of transport and welfare in municipality as well.

There remain several problems for calculation of operation cost. Refinement of the simulation models should be discussed in the future study, for example, to introduce the evaluation from the viewpoints of users as well as from operators.

Especially, it has been noticed that people tend to have more different travel expectations and unpredictable travel behaviors which is different from the previous time. They expect more flexible and personalized service from the mobility providers, otherwise they will be excluded from social community and it will be the reason for causing several health problems. This is also future study for the evaluation from the viewpoint of welfare benefits.

## REFERENCES


1) Wright, S., Emele, C. D., Fukumoto, M., Velaga, N. R. and Nelson, J. D.: The design, management and operation of flexible transport systems: Comparison of experience between UK, Japan and India, *Research in Transportation Economics*, Vol. 48, pp. 330-338, 2014.
2) Mulley, C. and Nelson, J. D.: Flexible transport services: A new market opportunity for public transport, *Research in Transportation Economics*, Vol. 25, pp. 39-45, 2009.
3) Nelson, J. D., Wright, S., Masson, B., Ambrosino, G. and Naniopoulos, A.: Recent developments in Flexible Transport Services, *Research in Transportation Economics*, Vol. 29, pp. 243-248, 2010.
4) Kishi, K. and Satoh, K.: Attitudinal study on a reciprocal community transport system in Japan, *International Journal of Sustainable Transportation*, Vol. 1, pp. 161-171, 2007.
5) Taxi subsidy scheme by ACT (Australian Capital Territory) government, Updated July 2018, Available at https://www.assistance.act.gov.au/adult/transport_and_registration/taxi_subsidy_scheme
6) Ishio, M., Yamanaka, H. and Sanada, J.: A study on characteristics of tax fare subsidy scheme in rural areas and its future, *Proc. of Infrastructure Planning, Japan Society of Civil Engineers*, Vol. 69, No. 5, pp. I_771-I_780, 2013. (in Japanese)
7) Davison, L., Enoch, M., Ryley, T., Quddus, M. and Wang, C.: A survey of demand responsive transport in Great Britain, *Transport Policy*, Vol. 31, pp. 47-54, 2014.
8) Derek Halden Consultancy, the TAS Partnership and the University of Aberdeen, Scottish Executive Social Research: Review of Demand Responsive Transport in Scotland, 2006, available at https://www.webarchive.org.uk/way-back/archive/20180602163313
9) Hayakawa, S.: Research on future of non conventional mobility service in local transportation, *The Japan Research Center for Transport Policy*, A-382, 2005. (in Japanese)
10) Hayakawa, S.: Taxi subsidy system for elderly can secure the mobility of residents: Case study of Tatebayashi city Gunma Prefecture and Oomachi city Nagano Prefecture, *Society of Public Utility Economics*, Vol. 57, No. 2, pp. 105-118, 2005. (in Japanese)
11) Moriyama, M.: Life and public transportation at hilly and mountainous area under depopulation and aging, *Housing*, Japan Housing Association, Vol. 59, No. 9, pp25-29, 2010. (in Japanese)
12) Community bus assessment guidelines, Hyogo prefecture government, 2008. (in Japanese) Available at https://web.pref.hyogo.lg.jp/ks05/documents/000178787.pdf
13) Inoi, H. and Fukumoto, R.: Research on the operation cost of "Fukushi-Yusho service" (special bus service for the disabled), Proceedings of Conference of Japan Society for Traffic Engineers, Vol. 30, pp. 417-420, 2010.



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