ROUTE POTENTIAL AS A CRITERION FOR PUBLIC SUBSIDY OF BUS SERVICE

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INTRODUCTION

Development of motorization in urban transport has been reducing the number of bus patronage and making some bus route impossible to keep themselves on their fare-box revenue. This fact is accepted widely in these days. Therefore in order to support the mobility of the people generally by keeping the bus survices in the city, it is necessary to subsidize the operational expenses by public funds. However, in Japan, the central government and local government are negative to subsidize because they are afraid that the introduction of subsidies makes the management of bus survices loose and the productivity lower.

Accordingly in this research we develop a method to distinguish the routes which need public subsidies and an index which can manage the productivity even under subsidies and we hope it contributes to realization of the introduction of public subsidies to the urban bus survices.

1. ARGUMENTS ABOUT PUBLIC SUBSIDIES TO URBAN BUS SURVICES

1.1. Necessity of public subsidies

The number of bus users has been decreasing as the number of private car users increases in urban transport. On the other hand people's ranges of daily life are becoming larger owing to motorization, so people who are not able to use private cars, for example young people and various handicapped people, depend more on bus services. Therefore actually operating length of bus survices are not reduced in spite of decrease in passengers.

As a result, some bus routes have become to be unable to compensate operational costs with their fare-box. Accordingly if governments (especially local governments) wishes to keep bus survices in order to support the people's mobility, they must subsidize such bus route with public funds.

1.2. Risks involved in public subsidies

However public transport survices in Japan are operated by private companies on self-supporting accounting system in principle and government are not actively inclined to introduce public subsidies. Because it is thought that the introduction of public

subsidies is against the principle of free competition among private enterprises. There are two concrete anxieties:

①Public subsidies deprive public transport companies of incentives for the efforts toward improving productivity and dissolving deficits.

②The level of survices is to be determined by the principle that fare-revenue should compensate operational cost strictly. Therefor if this principle is lost by the subsidies, the level of survices keeps rising and the amount of subsidies becomes larger and larger endlessly.

Consequently, in order to realize the introduction of public subsidies it is necessary to develop the ways to overcome two problems above. There are two processes in this way. One is to make an index which is able to measure the productivity of each bus route objectively, and the other is to think out a method to distinguish some routes that are hard to manage by self-supporting accounting system by nature.

1.3. Analyzing the cost-revenue ratio and the route potential

Thus far in Japan "the cost-revenue ratio" has been used as an index to measure the productivity of each route. It is calculated by dividing the revenue of a route by its cost. If public subsidies are introduced, the revenue includes subsidies, so the index does not show the productivity strictly. And the index can be developed as follows. It tells that the index includes many factors.

$$\underset{\text{A)}}{\frac{\text{revenue}}{\text{cost}}} = \underset{\text{A)}}{\frac{\text{revenue}}{\text{passenger·km}}} \cdot \underset{\text{B)}}{\frac{\text{passenger·km}}{\text{potential demand along the route}}} \cdot \underset{\text{C)}}{\frac{\text{potential demand along the route}}{\text{length of the bus route}}} \cdot \underset{\text{D)}}{\frac{\text{running·km of the bus route}}{\text{handle time}}} \cdot \underset{\text{E)}}{\frac{\text{handle time}}{\text{cost}}}$$

In this equation, D) shows productivity of survices strictly. B) shows the result of selling bus services. In a broad sense it is included in productivity. A) shows the fare level; it is not different in each route. C) shows the quantity of social activities that exist along each bus route and that can become bus users. It is different in each route and is determined by setting a route in an area in the city. And we decide that we call C) "the route potential". Here the potential means the power which is determined according to the place where a route is setted.

According to the interpretation mentioned above, the index of productivity B×D can be gotten by calculating the route potential of each route and then dividing it into the cost-revenue ratio

(because A) is constant). Furthermore the very route potential proves to be proper as the index to distinguish the route which need need public subsidies by nature (not because their productivity is low).

2. DEFINING AND MEASURING THE ROUTE POTENTIAL

2.1. Definition of the bus stop potential

The route potential is gotten by summing up the bus stop potentials P which is calculated every bus stop on the route. The bus stop potential P is not equal to the actual number of bus users of each bus stop. Some of bus stops realize the potential markedly, some of them do not so. However it is expected that they are interrelated on the whole comparatively well.

Now it is thought that the number of users of each bus stop is in proportion to the population and the quantity of socio-economical activities in the sphere of its influence. So by analyzing the relationship between the number of users and the quantity of various activities on 1,144 stops of municipal bus in Nagoya, the following equation is gotten:

$$P = (1.0Pr + 3.2Pb + 1.2Ps + 2.3Pe + 8.1Pm)Ri + Pt \quad \cdots\cdots \quad (1)$$

Pr, Pb, Ps, Pe, Pm mean the quantity of activities being within the circle with the radius of 500 meters from the bus stop (the length of the radius is corrected a little in case some bus stops stand close together), each uses the index shown in Table 1.

Table 1 Index representing each quantity of activity

		index	total	average(per bus stop)
Pr	resident	population	2,110,700	1,769
Pb	buisiness	employee	875,000	754
Ps	suburb	population	323,100	35
Pe	education	number of pupils	189 (schools)	196 (pupils)
Pm	medicine	number of beds	198 (hospitals)	24 (beds)

Ri is the coefficient which is multiplied when the bus stop is near a railway station.

$$Ri \begin{cases} = 0.0 & (\text{nearer than } 200\text{m}) \\ = 0.4 & (\text{from } 200 \text{ to } 700\text{m}) \\ = 1.0 & (\text{farther than } 700\text{m}) \end{cases}$$

And Pt shows the number of passengers who transfer from a railway to a bus (it is called the terminal potential), and the

number is added when the bus stop is in front of railway station. It is gotten from the data of railway side.

The equation mentioned above was gotten under the good corelation (r=0.579), so we determined to define the bus stop potential with the equation.

2.2. Difinition of the route potential

The route potential is calculated by summing up the bus stop potentials on each route and multiplying the following three coefficients:

①The coefficient which shows the relative ability of trip production in the area the route passes through (2.56 ～ 2.68 trips/person·day).

②The coefficient which shows the relative degree of dependence on public transport system in the area the route passes through (0.12 ～0.38).

③The coefficient which shows the relative degree of importance from the viewpoint of urban activity of the areas which are connected by the bus route (0.34～0.75).

2.3. Measuring the route potential

Nagoya municipal bus has 111 routes. The outline of them is shown in Table 2. Calculating the route potential of each, we get figures from 5.74 to 86.55. The average is 27.58. These mean the potential per one kilometer of the routes. The relation between this route potential and the number of passengers is shown in Fig.1. It tells because the potential is high, it does not always follow that the number of passengers is large. Here it is shown that productivity (B mentioned in 1.) is defferent on every route.

Table 2 Outline of NAGOYA municipal bus lines

	average	min.	max.
cost-revenue ratio	148	55	492
length	8.5 km	3.2	14.4
frequency	11.7 serv./hr	1	40
speed	12.6 km/hr	9.6	20.1
running km	1125 km	77	4753
passengers	665 persons/km	13	3122
influenced ratio by railway	50.5 %	10	100
route of competition	52.2 %	0	100
amounts of income/outgo	−15 million ¥/year	−137	390

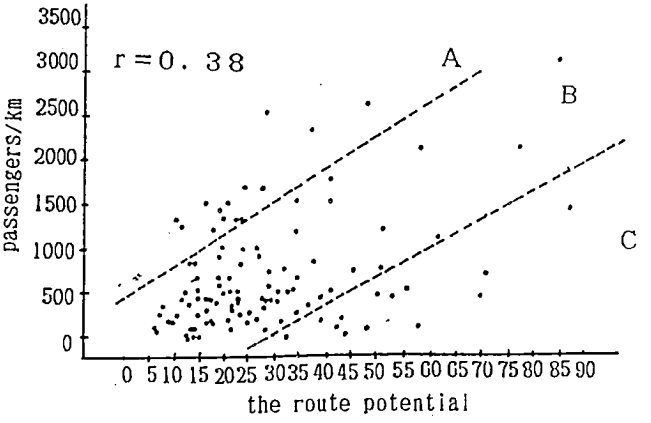

Fig. 1 Relation between route potential and number of passengers

3. MANAGEMENT OF PRODUCTIVITY BY THE STANDARD PATRONAGE MODEL

3.1. Making the standard patronage model

It becomes easier to manage the productivity on operating each route if two parts of a patronage (the number of passengers) variance are separated: the part which is explained by the character of each route like the route potential and the part which is thought to be a reflection of operating efforts. The route character includes not only the potential but also primary variables like the route length and how close to other routes.

Then we have developed multiple regression model which explains the number of passengers with the route potential and other characteristics of each bus route shown in Table 2 as explanation variables and have gotten the equation (2) (r=0.67):

$$Y=19.67X_1-10.64X_2-4.26X_3-10.54X_4+979.53 \quad \cdots\cdots(2)$$

Here Y means the number of passengers, X_1 means the route potential, X_2 means the length of the route, X_3 means the influenced ratio by the railway, X_4 means the rate of competition. X_3 (or X_4) shows the degree of competition between the bus route and the railway line (or a close bus route). According this model shows that the higher the route potential is, the more the number of passengers is, and the longer the length of the route is and the more the degree of competition with other route is, the less the number of passengers is.

We regard the equation (2) as the standard patronage model which shows the standardized number of passengers led from the characteristics by nature of each route.

3.2. Managing productivity by the ratio of the number of passengers

If a route has more passengers than the standard number of passengers calaulated from the equation (2), its productivity is good, and if not, it is bad. Meanwhile, as shown in Fig.2, the corelation between the actual number of passengers and the cost-revenue ratio is relatively good.

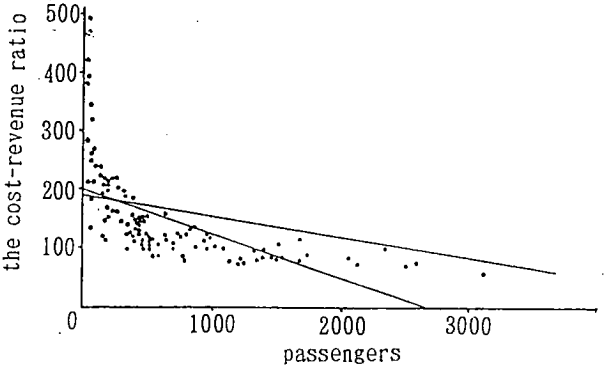

Fig.2 Relation between number of passengers and the cost-revenue ratio

So calculating the ratio of the actual number of passengers to the standard number of passengers (we call it the ratio of the number of passengers), we can estimate the productivity of each route. Fig.3 shows the ratio of the number of passengers of 111 routes. Among them, the routes whose figures are less than 0.7 may be considered as the low productivity route. Actually most routes whose cost-revenue ratio are low (the worst 15 route) are included in them.

4. DISTINGUISHING THE ROUTES WHICH NEED PUBLIC SUBSIDIES BY THE ROUTE POTENTIAL

It is clear from the large deficit of Nagoya Municipal Bus Service shown in Table 2 that there are some routes that have difficulty to compensate their operational costs with fare box revenue and that need public subsidies. Public subsidies, however, must not be the way to hide the bad productivity. It is afraid that subsidies may make the company lose its incentives for improving productivity. Therefore it is desired that the routes to be subsidized are distinguished strictly by the route potential mentioned above.

The left chart of Fig.4 shows the relationship between the

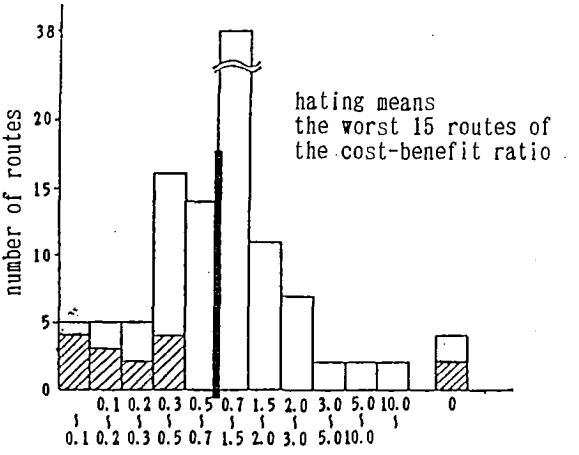

Fig.3 Distribution of the ratio of the number of passengers

amount of income and outgo and the route potential. There is much deviation, but the corelation between them can be found and a regression line in the chart can be thought to show their general relationship.

While in the right one of Fig.4 the amounts of income and outgo of each route are arranged in order of quantity. The routes from A to B are in the black and they make up the deficit of the routes from B to C. If such cross subsidy in a company is admitted, only the routes that stand the right side of C bring the deficit to this company. So they become to be proposed as the routes which can receive subsidies from the outside of the company. Then we can calculate the route potential which is correspond to the amount of income and outgo (the amount of shortage) of the route C using the regression line on the left chart, and we get PC. Here we call it the critical potential and regard it as the potential of the border which distinguishes the routes to be subsidized.

Thus if we determine the routes to be subsidized with the critical potential, we have no risk that we give subsidies to the routes which bring the deficit too much because of a deficiency of enterprise's efforts and bad productivity and make it lose its incentives for improving productivity.

Explaining in detail, as Fig.5 shows, the routes receiving subsidies place in the part covered with hatching in the area defined by the potential (P=PC) and the amount of income and outgo (m=0); the routes whose route potential is less than PC and whose amount of income and outgo is the red figures. The routes which are shown with the points in D are regarded as the routes to be subsidized from the viewpoint of the amount of income and outgo, but have enough potential and are thought to be able to improve their

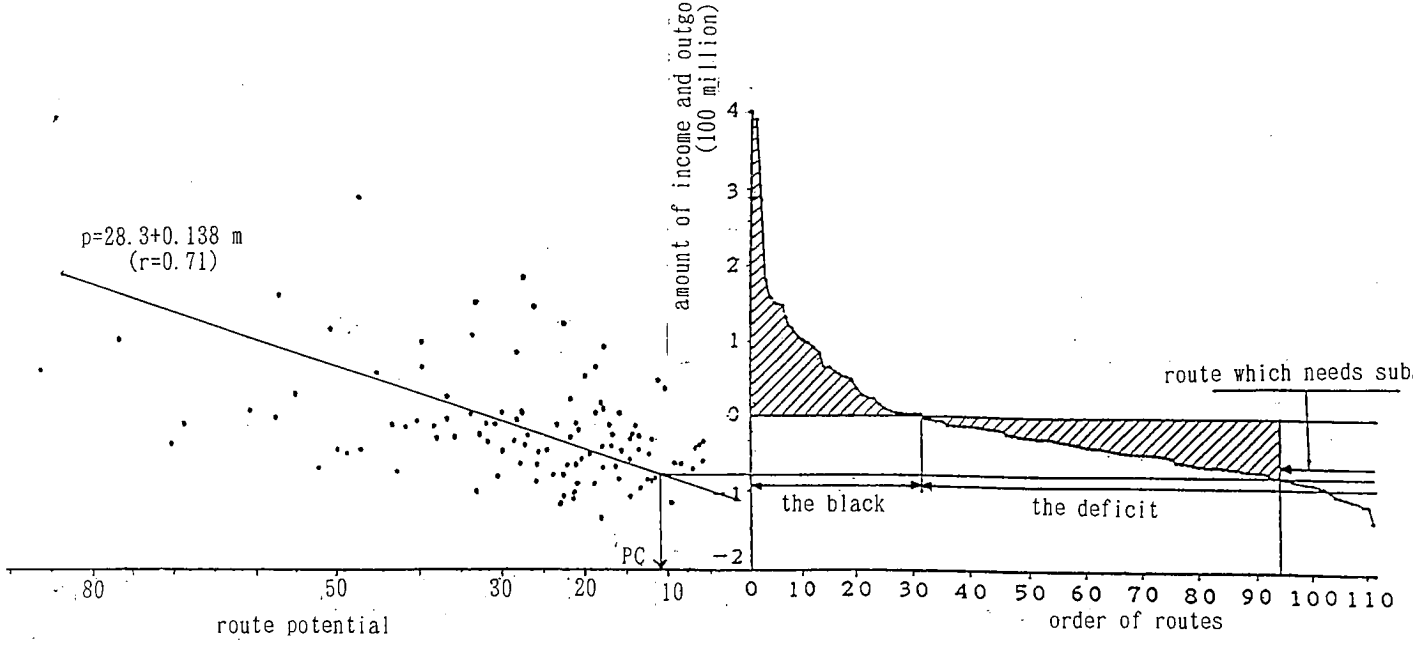

Fig. 4 Determination of critical potential

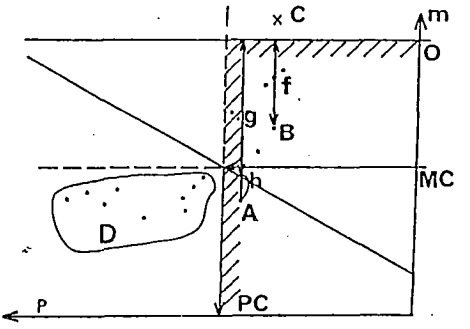

Fig. 5 Determination of subsidized routes and their amounts of subsidies

productivity by themselves without subsidies. And the routes like C have the less potential than PC, but they do not bring the deficit, so they do not receive subsidies.

Further, with this chart we can calculate the amount of subsidies for each route which need subsidies by longitudinal distance shown as f and g (not include h).

5. CONCLUSION

Bus survices are indispensable to keep the sound mobility of people in the city, and introducing public subsidies to the bus operation can not be avoided to keep them.

In this paper we show with concrete actual proof that two risks which put obstacles in the way of subsidies can be evaded by applying the route potential offered and managing the productivity based on it. That is to say, we can distinguish the routes which need subsidies by nature with this index, and develop the index of managing the productivity which is available even under subsidiary.

We hope by applying this menthod the management of municipal bus services will become sound in the city in which bus services are getting poor and poor and which is groaning under the increasing public subsidies.

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