Assessment of Strategic (Transport) Policy Objectives through the Application of a Macroscopic Model of the Regional Bus Transport Market

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1. INTRODUCTION

Public road transport continues to have an important role in the provision of service due to its relative flexibility, efficiency and affordability. Problems accompanying urbanization and growing social awareness has led to the increase of political and social pressures to have public road transport take on the following roles : Promotion of the environmental concerns through the efficient use of fossil fuels; efficient use of limited road space through the reduction of road congestion, and improvement of the general mobility of the citizenry. However, its effectiveness in such roles depends greatly on the conditions under which it exists.

Transport policies play a major part in helping public bus transport in achieving its objectives. In turn, these policies are defined in terms of strategic objectives - objectives which refer to aspects which are believed to be quantifiable and hence controllable. For example, as part of a policy of improving level of service, policy makers may set the strategic objective of raising operating speed levels. On the other hand, to operationalize policies of improving or protecting mobility, keeping fares low may be adopted. However, the achievement of these strategic objectives may not always necessarily achieve the stated policy objectives. This might be explained by the inappropriateness of the control variable (i.e. strategic objective variable) or the inappropriateness of the target level set for the variable.

This paper investigates a number of commonly considered strategic objective variables and the effect of changing them on the profit and total surplus situation under different scenarios. A macroscopic model, previously developed by the authors(a,b) for the case of Japanese bus transport, is used to model the demand and cost situation of an operator under different operating scenarios and their possible actions under such conditions. In contrast to the previous, this paper would like to focus on evaluating so three transport policy related issues : 1) operating speed, 2) car ownership; and 3) fare levels and wages.

Chapter two contains examples to introduce the basic procedures of analysis, and also appears in two yet unpublished papers. Chapter three contains the analysis of strategic objectives. Chapter four contains the conclusions of this paper.

2. BASIC APPLICATIONS OF THE MODEL TO ANALYSIS

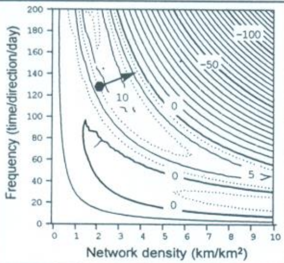
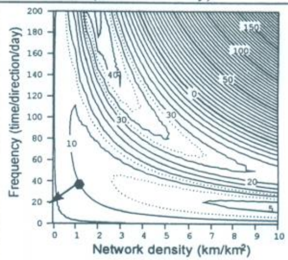
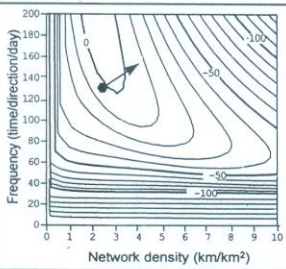
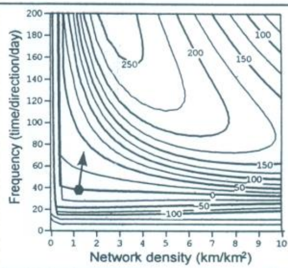
The following applications are an attempt to clarify the impact of the choice of the level of service on the operator profit, as well as the total surplus. Total surplus is defined for the purposes of this analysis as the sum of the user surplus and operators' profit. Keeping all other variables constant, the effect of different scenarios for network density and frequency can be mapped to produce a set of isocurves describing profit and total surplus. By comparing the management "maps" of different operators, it is possible to make some assessments. The results of these applications are discussed in the following sections.

2.1 Assessment of the Operators Management Strategy Regarding Level of Service

This section compares two private operators under similar environmental conditions, but having dissimilar levels of service. The net effect to them is that they have different levels of profitability and their management maps will lead them to make different decisions about the direction they should take in deciding a suitable level of service.

The figures shown in Table 1 indicate the isovalue curves for profit and total surplus (all iso-curves are in units of millions of yen per year). The vertical axis corresponds to the frequency of service(trips/direction/day) while the horizontal curve indicates the route density(km./sq.km.). The zero profit line corresponds to a break-even situation where all costs, including the salaries of workers are covered. The point and arrows indicate the present level of service and desirable direction to be taken from that point. This indicates the direction of the steepest increase for profit or total surplus from the point corresponding to the existing level of service.

Table 1. Comparison of Operators Under Similar Environment Conditions, but with Different Levels of Service

Aspect \ Operator	A (PD = 5808persons/km^2) (OS=26.6km/h) (ND=2.02 km/km^2) (Fr=126 times/day)	B (PD = 4708persons/km^2) (OS=22.4km/h) (ND=1.24 km/km^2) (Fr=38 times/day)
Profit (100 million Yen)	 	
Total Surplus (100 million Yen)	 	

From the viewpoint of the role of government, the indication is that a different approach is appropriate in each case. For company A, there is apparently no need for government to restrain or support, since the operator, if he follows the profit motive, it will coincide with an increase in total surplus. In contrast to this, operator B if allowed to follow its "short-sighted" view of how to improve its profit, it may adopt a reducing management direction, which is counter to the protection of total surplus. Reasons for "short-sightedness" might be one or two of the following : limited ability to finance expansions, regulations making it difficult to change routes or frequencies.

Thus a prescription for these two cases may be as follows : For operator A, no action need be taken except to monitor any changes in the operating market. Or alternatively, deregulation of the selection of routes or frequency. For operator B, some support could be provided in the form of advising the company of the potential profitability of higher levels of service, help in making a market survey to determine potential areas for expansion. If potential is determined, an offer of low-interest loans for the acquisition of new vehicles and other initial costs that are incurred will make it possible to raise the level of service. This type of action would be in the public interest, and due to the possibility to improve profitability, it is inherently sustainable, so long as the appropriate level of service is reached.

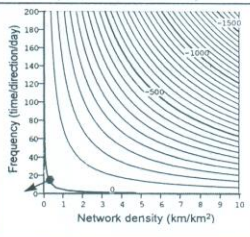
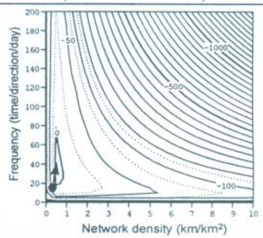
2.2 Case of Need for Public Support

This section illustrates the case where an operator is faced with a "harsh" environment (population density of 165 persons/square meter) wherein increase of profit can not be attained without lowering the level of service offered.

However, it is also necessary to protect the public interest, and maintain a certain level of service. In fact, in the example presented here, the achievement of the maximum level of total surplus is possible with a small increase of service level, especially frequency.

This thus presents a supporting argument for the need to provide subsidies in some cases, at least for the maintenance of existing service, especially in cases where operators can not secure a reasonable profit.

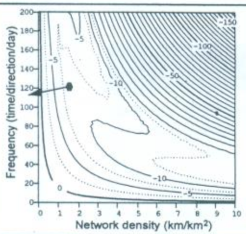
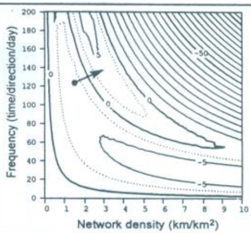
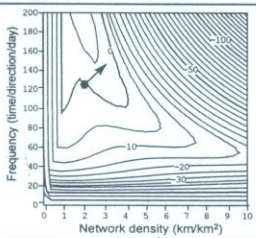
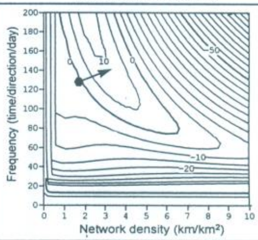
Table 2. Profit and Total Surplus in a Harsh Operating Environment

Characteristics	Profit (100 million Yen)	Total Surplus (100 million Yen)
(PD=165/km^2) (OS=42.5km/h) (ND=0.22km/km^2) (Fr=15times/day)		

2.3 Effect of Privatization

This application deals with the identifying whether the a change in the type of management might have any significant impact on the performance of an operator. It was assumed a priori that this would most likely have an impact on the cost structure of the operators. To make a comparison, the data of one of the samples of public company operator was used, however, changing the specification of the management type (MT), dummy variable. As it will become obvious upon examination of the cost, profit and user surplus curves, the model predicts a significant impact on the selected public operator.

Table 3. Modeled Before and After Cases of Privatization

Case / Aspect	Before	After
Profit (100 million)		
User Surplus (100 million Yen)		

Close examination of the profit curves reveals that the desirable direction for any changes in the operating variables of network density (km/km^2, horizontal axis) and frequency (trips/direction/day, vertical axis) are diametrically opposed. The before case shows that a "retiring" action is appropriate, implied by the higher values of profit at lower levels of network density and frequency. However, the opposite case exists for the "privatized" operator.

On the other hand, total surplus values are shown to be open to improvement in similar manners, increasing network density and frequency by a certain degree.

3. ASSESSMENT OF POLICY OBJECTIVES

The basic idea behind this kind of assessment is that not all policy actions necessarily achieve their stated objectives. A number of scenarios are investigated in order to clarify the connection between policy targets and their achievement (or non-achievement) of objectives. This analysis proceeds by first defining a policy target and stated objective. This policy target is used as a input to a set of scenarios which clarify the tendency (and direction) of operators to change their level of service, in terms of frequency of bus service and route network density. Profit and Total Surplus Increase (TSI) are used as the basis for the assessments. For the purpose of this analysis, TSI is defined as the difference in profit plus the change in user surplus. The following analyses are applied to one operator providing service of Network Density equal to 2.92 kilometers per square kilometer, Frequency of 126 buses/direction/day and with an Operating Speed (OS) equal to 15.9 kilometers per hour. The region has a population density of 5,808 persons/square kilometer, with a car ownership rate of 0.383. The maximum peak hour road speed is 26.6 kilometers per hour.

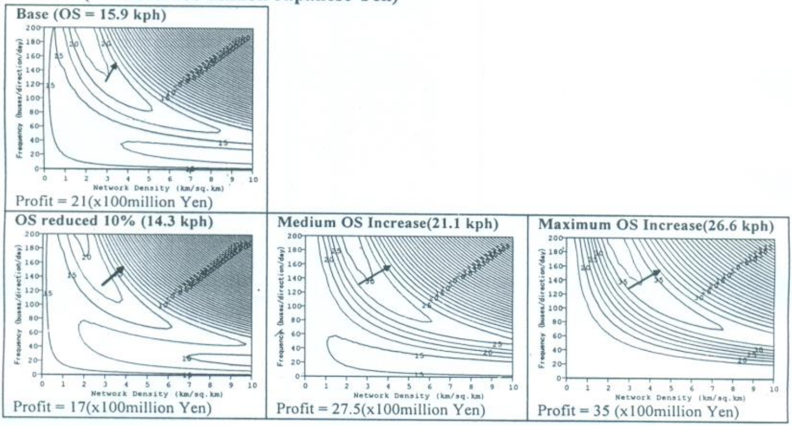
3.1 Operating speed

Relatively high operating speed is one of the reasons why users often turn to using private vehicles. Thus raising the speed of bus service is perceived as an important step to promoting the use of its services. In relation to this, it is necessary to see how raising (or lowering) speeds affects his level-of-service provision behavior.

The scenarios considered are as follows :

1) 10 % reduction in the present operating speed.
2) Raising the operating speed to the maximum peak time road speed[1].
3) Raising the operating speed to the mid-point between the present operating speed and the maximum peak time road speed.

Table 4. Profit Isocurves for Various Operating Speed (values in 100 million Japanese Yen)



Profit isovalue curves for different combinations of Frequency (buses/direction/day) and Network Density (km of route/sq. km of service area) are graphed (Table 4). All other variables (aside from Fr, ND and OS are kept constant). The arrows shown indicate the direction of the gradient at the present level of service, shown by the foot of the arrow (Fr=126 buses/direction/day ; ND = 2.92 km/sq. km). The length of the arrow is irrelevant. Assuming that the operator follows the profit maximizing objective but has only a "limited" perception of the impact of changing his level of service, he is expected to follow the gradient. Using this procedure, two important observations can be made from Table 4 :

1) higher OS levels correspond to higher profit levels - this can be explained by the fact that less vehicles will be needed to provide frequent availability service. Also, less vehicles require less garage space. At the same time, higher operating speeds allow more efficient use of fuel. This is translated into less total costs.

[1] Maximum road speed = maximum attainable speed by all road vehicles in the peak hour in the given operating region.

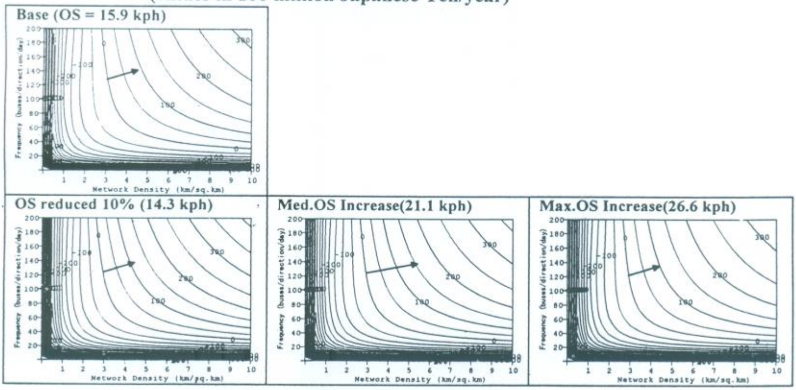
2) marginal increases of profit to changes in Fr and ND are higher at higher levels of OS - this is shown by the closeness of iso-profit curves. Thus we can say that the "steepness" of gradients with respect to the profit isocurves is greater at higher OS levels. This demonstrates the importance of protecting or improving the OS level of operators. In such situations, operators can gain higher marginal increases in profit with respect to raising their Frequency and Network Density. This indicates that operators would have greater incentive to increase there service levels (in terms of Fr and ND) at higher OS levels because it is easier to get a return on their investment. In addition, we can also calculate the elasticity of increase in Profit to increase in OS :

Scenario	Elasticity of Profit Increase to Increase in Operating Speed
OS reduced 10% (14.3 kph)	1.584
Med.OS Increase(21.1 kph)	1.043
Max.OS Increase(26.6 kph)	2.457

From this table it is easy to see that profit grows proportionally more quickly than OS rises. This further supports the notion that operators can find greater incentive to increase their level of service and thus raise their profit under higher OS levels.

Aside from profit curves, the net Total Surplus Increase (TSI) is shown in Table 5, corresponding different frequency, network density and operating speed. Total surplus increase (or decrease) is the net change in User Surplus plus the change in bus company's Profit, corresponding to the change in Fr and ND. From these graphs, it can be observed that the marginal gain in TS for changing Fr and ND at higher OS levels is lower. It shows that if operating speeds are raised, it becomes more difficult to raise the TSI by a given increase of ND or Fr. In the reverse case, if operating speeds are allowed to deteriorate (eg. due to congestion), it becomes easier to raise TS by a change in ND or Fr. Due to the fact that this analysis is only dealing with a net change in TS, it is difficult to conclude about the meaning of this situation. However if TSI can increase or decrease more quickly at low levels of OS, with respect to changes in ND and Fr, then we can say that as OS decreases, it becomes more and more urgent to at least protect the existing ND and Fr levels.

Table 5. Total Surplus Increase Isocurves for Various OS (values in 100 million Japanese Yen/year)



3.2 Car Ownership

Motorization is often viewed as contributing to the demise of public transport systems in many cities. The rationale for controlling ownership is a matter of controlling the choice set of transport users. To investigate how Car Ownership Rate (ratio of cars to total population) affects the profit and total surplus improvement situation of the operator, the following scenarios were considered :

1) 20% increase of COR
2) 50% increase of COR

Results are shown in the following table .

Table 6. Profit Isocurves (values in 100 million Japanese Yen)

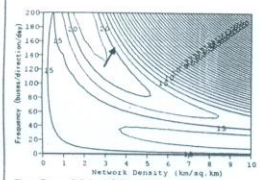
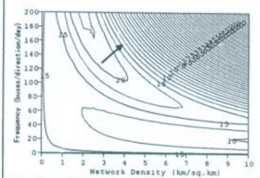
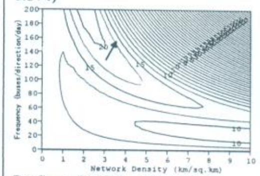
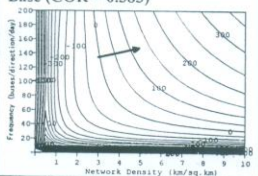
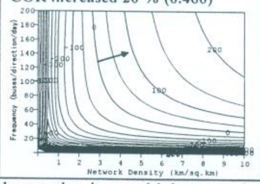
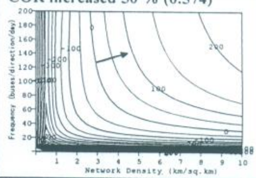
Base (COR = 0.383)	COR increased 20 % (0.460)	COR increased 50 % (0.574)
		
Profit = 23(x100 million Yen)	Profit = 21(x100 million Yen)	Profit = 18(x100 million Yen)

Table 6 clearly shows the trend of increasing COR resulting in lower profit levels for the operator. However, the elasticity of the profit loss with the respect to a rise in COR is as follows :

COR Scenario	Elasticity of Profit to COR
20% increase	-0.296
50% increase	-0.319

This shows that as COR grows, profit is reduced by a greater proportion. This means that as car ownership increases the *tendency* for the profits of the company to be reduced also increases.

Table 7. Total Surplus Improvement Isocurves (values are in 100 million Japanese Yen)

Base (COR = 0.383)	COR increased 20 % (0.460)	COR increased 50 % (0.574)
		

On the other hand, Table 7 shows the it would be marginally more difficult to improve welfare levels by increasing the level of bus service when COR increases. This is shown by the steepness of the TSI curves which become less and thus a greater increase in level of service would be necessary to achieve the same TSI in the base situation. This can also be interpreted as : it is more difficult to improve the attractiveness of bus transport when COR is relatively high.

3.3 Fare and Wages

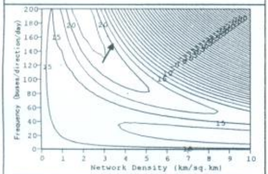
Purchasing power of users is determined by the relationship between the relationship between the amount of money the have (wages) and the money that the spend (fare). Thus keeping fares low has often been implemented as a means to preserve the share of the demand. However, unnecessarily low fares makes it difficult for operators to improve the quality of their service over time. This means that it is necessary to know what level of fare (or change thereof) is appropriate for a given situation. This section considers the following scenarios :

1) wage of bus company employees goes up 25%, users wage is the same, fare remains the same
2) wage of bus company employees goes up 25%, users wage is the same, fare goes up 25%
3) wage of bus company employees goes up 25%, users wage goes up 25%, fare goes up 25 %

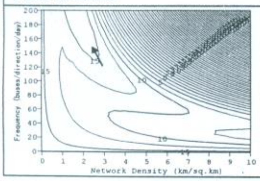
The first scenario corresponds a situation wherein demand for the company's service will remain the same, but the operating costs increase. The second scenario depicts the case wherein the company seeks to offset the rise in personnel cost by raising the fares proportionately. In this case demand will be reduced. The third case corresponds to when operators will seek to pass on the costs of the employees wage increase to the users by raising fares proportionally, however, wages of users also increase by the same rate. This is interpreted such that the users' "virtual" fare (fare perceived upon which they will act) remains the same. Thus demand will be the same as the base case, but the expectable profits will be different.

Table 8. Profit Isocurves for Wage and Fare Scenarios (values in 100 million Japanese Yen)

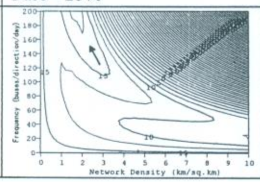
Base Situation



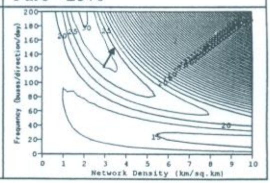
Company Wage +25%
Users Wage is same
Fare is same



Company Wage +25%
Users Wage is same
Fare +25%



Company Wage +25%
Users Wage +25%
Fare +25%



From the first scenarios' profit-LOS figures, we can observe that the profitable region has shifted slightly away from the present level of service. At the same time, the operation level selection tendency of the operator has shifted towards the ND reduction direction. In contrast to this, the second scenario shows that the operator was able to retain some profit, but the revenue was unable to defray the expenses. The third scenario shows that if users do not perceive the increase in fare as significant, then the operator can expect to have the most favorable situation in the third scenario. In addition, from the user viewpoint of level-of-service, the last scenario also indicates some tendency of operators to at least keep the present level.

These illustrate the importance of being able to recognize situations wherein raising fare is acceptable, from the viewpoint of keeping operators' desire or willingness to maintain or increase the level of bus service, in conjunction with the operators sustainability.

4. Conclusions

The findings of these analyses can be summarized as follows :

- Protecting the operating speed of operators can be an important indirect way of providing incentive to operators for raising their level of service.
- Within the bus market model, the increase of car ownership affects the gross profit and the marginal ability to increase profit. This means that controlling car ownership may be able to protect the financial viability of public transport/bus operations, as well as protecting its relative attractiveness.
- It is indicated that allowing a fare increase may be acceptable as a means of maintaining operators' desire to maintain a high level of service.

5. References

a) (To be published) Ieda,H., R. Watanabe and C.Diaz. Macroscopic Modeling of the Bus Transport Market Considering the Modal Competition/Coalition and Its Application to Management and Policy Assessment. Journal of the East Asian Society for Transportation Studies. Seoul '97

b) (To be published) Ieda, H. R.Watanabe and C.Diaz. Macroscopic Modeling of the Regional Bus Transport Market and Its Application to the Assessment of Management Strategies and Transport Policies. IATSS Review. 1996

c) Ieda, H. R.Watanabe and C.Diaz. Macroscopic Modeling of the Regional Bus Transport Market and Its Application to Management Assessment in Suburban Services. IATSS Research. 1996

d) Jeyandran, S. Management Analysis of Public Bus Transport System. Unpublished Master Thesis. Faculty of Civil Engineering. University of Tokyo. 1995

e) Douglas, N.J. An Econometric Investigation into the Demand Function for U.K. Bus Express Coach Travel During a Period of Deregulation. Transport Research Forum. October. 1984

f) Wabe, S. and O.B. Coles. The Short-run and Long-run Cost Function of Bus Transport in Urban Areas. Journal of Transport Economics and Policy. 1975