WHEN DO RAILWAY OPERATORS INVEST THEIR MONEY IN CAPACITY DEVELOPMENT PROJECTS ?

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abstract: Commuter railways in Tokyo Metropolitan Area have large share passenger transport and they have been required to plan and launch Capacity Development Projects. The authors propose that the railway operators make decision for Capacity Development Projects by 2 types of *social pressure*. In this study the authors analyze the historical data of four-tracking projects in Tokyo area and propose the criteria whether the operators launch the investment or not by explaining the 2 types of *social pressure*.

1. PREFACE

Commuter railways have been shouldering the major part of passenger transport in large cities, since their lines were constructed being accompanied by the rapid inflow of population from rural area to Tokyo region and the furious residential development from 1920s (Ieda, 1994). One of the most serious current problems of commuter railway transport in this area is their poor quality of transport in terms of "*congestion*" in vehicles. 200% (7 to 8 passengers have to stand in one square meter area) is the typical load factor in congested radial lines in Tokyo region in peak-time.

Both transport capacity and other quality oriented facilities have been improved somehow in these twenty years by the operators' investment. Some financial support system of the government for private railways' improvement projects are developed: such as the subsidy system for interest support or the previous deposit system for the improvement. Nevertheless, the problem is still unsolved. 150%, which is the goal proposed by the governmental council, cannot be easily believed to be realized in the future.

Passengers' willingness to pay for the improvement is evaluated and proved to be considerably high (Ieda, 1993). Operators, However, do not take risks to make the large-scale investment for the improvement of existing lines, because it requires the large amount of money and does not fairly develop new demand and profit. To tackle the problem, there will be various approach, such as cost reduction analysis for investment, institutional study, passenger's behavioral study, theoretical study on benefit and cost of improvement and historical approach. This study specially focuses on the operator's decision making criteria for investment, based on the historical analysis of already launched or given-up cases of capacity projects.

2. BASIC MODEL OF OPERATOR'S INVESTMENT DECISION MAKING

2.1 Characteristics of the situation

The industry's decision making behavior can be marked as so-called "*profit maximization with cost minimization sub-program*" under several given technical constraints (Varian, 1990). The situation of railway operators which this study deals with, however, has two distinctive points:
Firstly, railways have been occupying the giant share of commuter trips of their own franchising operation areas for long, which reaches to 70 to 90 percent of passenger trip in the case of Japanese large cities. The traffic demand is mostly captured for them already except for some special cases such as large scale residential developments. In this sense, the market is a kind of regional monopoly where the demand is somewhat non-elastic at least in terms of the improvement of the existing network. Secondly, the fare is strictly regulated so that it can compensate just for their supply cost and pre-determined reasonable profit which is the function of the amount of the property. Therefore, operators have no motivation to get more profit either by acquiring more demand, by putting the monopolistic fare on passengers or by putting maximum effort for reducing their supply cost.

In these situations, what can push operators to investment for the improvement of level of the transport service? What will restrain them from that? The authors propose behavioral criteria for these situations,such as monopolistic operators' investment decision making for the improvement of the level of service under the break-even fare control. The basic concept of the criteria is that operators launch or give up their project by considering the "***social pressure***" requesting both better quality of production and less cost.

2.2 Double kinds of pressure on operators

The upper mentioned social pressures are defined as the following two kinds:

Pressure for Better Quality of Transport (PBQT):

Both passengers and people have been putting the never-ending request on operators to provide the production with better quality. Faster, more frequent..., but "*less congested transport*" has been doubtlessly the most desired dimension. The level of the pressure will be measured by transport quality related factors such as congestion rate.

Pressure for Less Expensive Fare (PLEF):

The fare of commuter railway is regarded as one of those which directly and firmly affect people's life. The public in general is sensitive both to the level of fare and to the possible increase of fare. This pressure will be evaluated by several fare related indices.

Obviously, the former pushes operators for the investment, and the latter restrains. The authors assume the following criteria of operators investment behavior:

Basic Model of Operators' Behavior

Operators launch investment project for the improvement of the level of service, only when the following two conditions meet:

Condition 1: *The present level of service is too low to dodge the first social pressure.*

Condition 2: *The future increase of fare for the improvement would not be so large to wake the second social pressure up.*

3. CASES FOR THE STUDY

There are many options to increase railway capacity and these can be classified roughly in 2 types, that is, whether it goes with constructing new tracks or not. The former is :

1) Extension of existing lines
2) Construction of new lines
3) Construction of new tracks along the existing lines

The latter is:

1) Increase in number of train operations
   - Increase in number of cars
   - More frequent train operation
2) Increase in train floor space
   - Longer trains - extension of platforms
   - Double-decker trains
3) Improvement of operation schedule
   - Improvement of train type and stop pattern
   - Convenient transfer, Smooth movement of passenger

Although the latter way costs comparatively lower, the limit of capacity is restricted in this case.

In this study, the focus is on four-tracking projects planned or carried out in suburban railways of Tokyo Metropolitan Area. Four-tracking projects are to relieve the lack of capacity. However, they request much larger cost than other non-infrastructure measures. Figure 1 shows the sections which have or will have more than four-tracks.

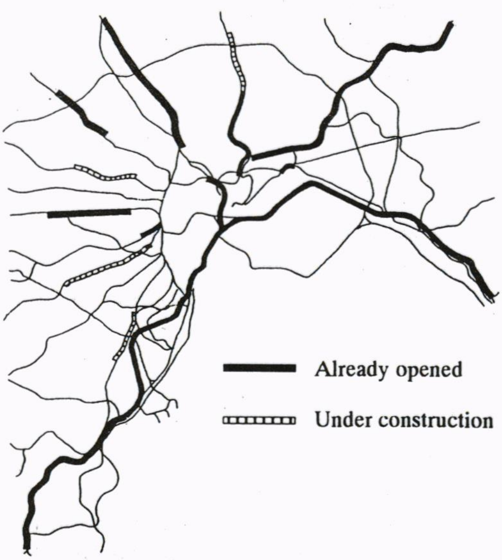

Figure 1. The sections which have more than four tracks

Table 1. The four-tracking projects picked up in this study

	Company	(km) Length	The year of opening	Maximum Load factor (year)
1	JNR	116	1970s	285% (1964)
2	Tobu	6.3	1974	230% (1967)
3	Odakyu	9.2	Finally canceled	232% (1970)
4	Seibu	5.4	Finally canceled	224% (1970)
5	Keio	12.5	Canceled	224% (1970)
6	Keio	3.9	1978	228% (1972)
7	Tobu	9.4	1988	220% (1975)
8	Odakyu	10.2	Under construction	208% (1988)
9	Seibu	18.4	Finally canceled	208% (1988)
10	Seibu	5.4	Under construction	208% (1988)
11	Keio	11.9	Canceled	189% (1988)
12	Tokyu	12.0	Under construction	195% (1988)
13	Tokyu	20.7	Under construction	204% (1995)
14	Seibu	18.2	Canceled	196% (1995)

1) From 1972 the interest supply system was applied
2) From 1987 the 'deposit' system was applied

In this study, 14 four-tracking projects are picked up under the conditions shown below: (table 1)

i) Projects of private or semi-private railway operators
There are many types of railway operators. Mainly we can classify them into Japan National Railways (JNR, now private JRs), 'Private' railways and Subway lines. The latter one is receiving much larger amount of governmental subsidy, and their networking and decision making for construction are much more influenced by governmental intervention. The authors adopt the former operators' case.

ii) Projects after 1960
Before 1950s, social and economic conditions were extraordinary different from now.

iii) Projects with enough data available.

4. METHODOLOGY OF THE STUDY

Some of the projects were really launched and others were finally not put into practice. This study tries to explain the decision making process of railway operators by analyzing data of these projects: to find, firstly what will be the principal factors for the operators' management view point, secondly to what extent they will affect.

For the analysis, at the beginning the authors calculate the amount of repayment against the investment, and then estimate the amount of fare increase and its ratio of fare increase. The authors adopt the data at the time of operators' decision making to explain the mechanism of the decision making process of the operators.

4.1 Assumptions

1) All the amounts of investment for the projects were assumed to be dependent on the loan system except the cases in which the 'deposit' system, mentioned before, were applied, because the fare regulation says that operators may not get to exceed profit for investment beforehand. In the actual case, some of the projects can utilize, to some extent, the operators' on fund, however, opportunity cost of them is equivalent to the case depending loan system.

2) From the opening year, railway operators repay the same amount of the loan for 25 years including the interest of construction period. In this repayment, the government subsidizes a part of interest to the projects after 1972, and in this case the ratio of interest is different from that of construction period.

3) Basically the authors assume that the railway operators raise the fare in opening year of the project, which can completely counterbalance with the uniform annual repayment per year. In 1987, however, a new system was introduced. When railway operators invest in large scale capacity development projects, they can put aside of fare revenue as the 'deposit' in advance to the opening from their fare revenue at maximum 10 yen per one trip in the construction period. In 1987 they are allowed to reserve maximum 1/4 of total investment during the term of construction, and from 1995 the ratio was relieved to 1/2. After opening years they must withdraw the deposit evenly for 10 years.

4.2 Definitions of indices

a) Basic variables

t	; Year
t_1	; "Decision Making Year" : The year when the operators decide whether they carried out the plan or not. And assume that they start construction from t_1.
T	; Expected term of construction
t_2	; "Opening year" : The expected year of opening (completion of the construction)
$RV(t)$	; Total annual revenue of operators at t derived from it's railway operation excluding the following deposit S.
F	; Investment for construction cost calculated by operators at t (Interest is not included).
$V(t)$	; Passenger volume in terms of total annual passenger-kilometers at t.
i	; Rate of interest of construction period
i_0	; Annual rate of interest after the opening.
S	; Annual 'deposit' before opening.
S'	; Annual 'deposit' withdrawal from the accumulated deposit.

b) Indices to explain operations' decision making criteria

$L(t)$; *Load factor* : Passengers divided by the capacity at t. (The capacity in Japanese commuter railways generally includes the specific number of standing passengers.)

The authors expect that this load factor represents the level of *social pressure* of the first category (PBQT). This analysis adopts the load factor only at t_1 from the following reasons.

i) Passengers are thought to respond to the present circumstance.

ii) Load factor in the opening year will not so seriously affect passengers' response compared to that at t_1, because the term of construction is about 10 years, and both passengers and operators know well that the demand have not increased as its assessment at t_1 from their experience.

$RP(t)$; Annual repayment of operators at t.
$RP(t_2)$ can be calculated as mentioned 4.1 2).

$\Delta RV(t_2)$; The annual increase of whole revenue at t involving the annual revenue, RV, deposit S and withdrawal S'.

As it is mentioned that expenditure including repayment equalizes the revenue, the following expression will be derived.

$$RP(t)=RV(t)-RV(t') \quad t \geq t_2,\ t' \leq t_2 \tag{1}$$

therefore

$$RV(t)=RP(t)+RV(t') \tag{2}$$

In the equation (2), the first term represents the payment for the project, the second term does for already existing expenditure such as operation cost and payment for already completed investment. And the new revenue will be determined to cover the both cost. Therefore, in the ordinary case,

$$RP(t_2-1)=0 \text{ and } \Delta RV(t_2)=RP(t_2) \tag{3}$$

but in the case so called 'deposit' system, $\Delta RV(t_2)$ varies depending on years, that is, this value $\Delta RV(t_2)$ will be non-zero at three times: Beginning to deposit at t_1, beginning to repay at t_2, after finishing withdrawal. Therefore, this system can reduce rapid increase of repayment. In the typical deposit case, $\Delta RV(t_2)$ is the largest in the second time when beginning to repay at t_2, and this value is $\Delta RV(t_2)$. This is calculated as follows:

$$\begin{array}{rl} & RV(t_2) = RV + RP(t_2) - S' \\ -) & \underline{RV(t_2-1) = RV + S} \\ & \Delta RV(t_2) = RP(t_2) - S' - S \end{array} \tag{4}$$

$f(t)$; The rate of fare for unit passenger-kilometers

$$f(t) = RV(t)/V(t) \tag{5}$$

$\Delta f(t)$; The increase rate of fare at t for unit passenger-kilometers

As mentioned in chapter 2, the operators will assess how much the fare will increase and how much it will repel the passengers. From this view point, as far as the passenger volume is expected to increase somewhat, the present V, which can provide the less number of passengers, can be used so as to evaluate this effect in the safer side. Therefore in general case, $\Delta f(t_2)$ takes the maximum number at t_2.

$$\Delta f(t_2) = \Delta RV(t_2)/V(t_1) \tag{6}$$

r_f ; The ratio of fare increase at t

$$r = \Delta f/f = \Delta RV/RV \tag{7}$$

Table 2. The data of the four-tracking projects

	Company	t_1	* $RV(t_1)$	* F	** $V(t_1)$	Year T	% i	% i_0	(1985=100) Price Index
1	JNR 1)	1964	111.8	247.0	5330	7	8	8	33
2	Tobu	1967	14.8	14.9	703	7	8	8	35.9
3	Odakyu	1970	13.6	37.4	647	7	8	8	37.5
4	Seibu	1970	12.2	32.9	518	7	8	8	37.5
5	Keio	1970	8.8	62.6	327	7	8	8	37.5
6	Keio	1972	11.6	27.1	368	7	8	6.5	42.0
7	Tobu	1975	35.8	50.1	920	7	8	5	64.7
8	Odakyu	1988	72.5	256.3	1087	10	8	5	100.9
9	Seibu	1988	66.4	253.8	905	10	8	5	100.9
10	Seibu	1988	66.4	92.5	905	10	8	5	100.9
11	Keio	1988	52.2	370.0	627	10	8	5	100.9
12	Tokyu	1988	82.5	210.8	645	10	8	5	100.9
13	Tokyu	1995	112.7	422.1	884	10	6	5	105.0
14	Seibu	1995	88.9	382.5	958	10	6	5	105.0

* Billion yen

** 10 million passenger-kilometers

1) RV is only in Tokyo Metoropolitan Area and both from passengers and freight

These financed or price related indices are expected to represent the second type of social pressure (PLEF) which will show the opposition of the passengers' response to the fare increase. Therefore there can be several different fare increase hypotheses:

1) Which indices the passengers respond, the amount of fare increase (Δf) or fare increase rate (r_f) ?

2) Which indices the passengers respond, the maximum fare increase (calculated by $\Delta RV(t_2)$) or total fare increase (calculated by $RP(t)$) ? *

* This hypothesis is like the Chinese proverb "Three for breakfast and four for supper". It means: the owner of monkeys gave their food 4 units for every meal and one day he proposed his monkeys to reduce 1/4 of their food only for breakfast. It was just before the breakfast and monkeys got very angry. Then the owner changed his plan and he proposed that he reduced their food in supper. And monkey jumped for joy for his proposal. This proverb says that it is silly to judge only from the present circumstance.

5. RESULTS OF ANALYSIS

5.1 Basic Analysis

The authors calculate the amount of repayment $RP(t_2)$ and $\Delta RV(t_2)$ and analyze the relation between annual revenue and annual repayment. At first, figure 2 shows the relation between the amount of repayment in the opening year ($RP(t_2)$) and the revenue ($RV(t_1)$) in the Decision Making Year, and these data are *real amount* converted by *the Consumer Price Index (1985 base).*

These points in figure 2 are plotted neglecting the contribution of the deposit system, therefore the vertical axis represents the nominal annual repayment. From this figure, generally speaking, it can be said that if the amount of repayment is higher compared to the revenue, projects tend to be canceled. The authors can also say that Tokyu'88, Odakyu'88, Tokyu'95, which were launched, are required comparatively higher repayment and that the projects which were carried out by JNR from 1964 is especially large investment.

And the authors analyze in the case of the marginal revenue ($\Delta RV(t_2)$) and show the result in figure 3. In this case, clearer separation of launched and not-launched can be obtained. It can be said that this value $\Delta RV(t_2)$ represents the second pressure more clearly.

5.2 Congestion and Fare Increase

The ratio of fare increase (r) and the amount of the fare increase per passenger per km (Δf) can be obtained from the amount of marginal revenue of operators ($\Delta RV(t_2)$). It is these values and load factor that directly influence passengers' response. Figure 4 and figure 5 show the relation between load factor and fare information. In this case the data of fare are also on 1985 base.

From these analysis, it can be said that the minimum congestion level that operators launch the projects is approximately more than 200%. This limit looks to get reduced year by year reflecting the growing preference for the better ride comfort of the passengers.

This study assumes that operators will determine the project "to be or not to be" considering the social pressure. Our 14 projects will be plotted in the space which is orthogonaly

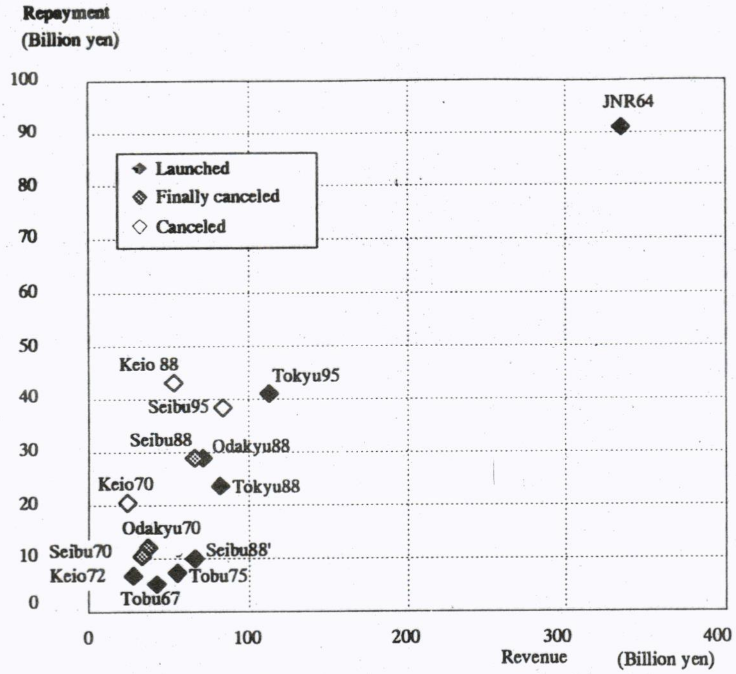

Figure 2. Repayment in opening year and revenue in planning year (1985 base)

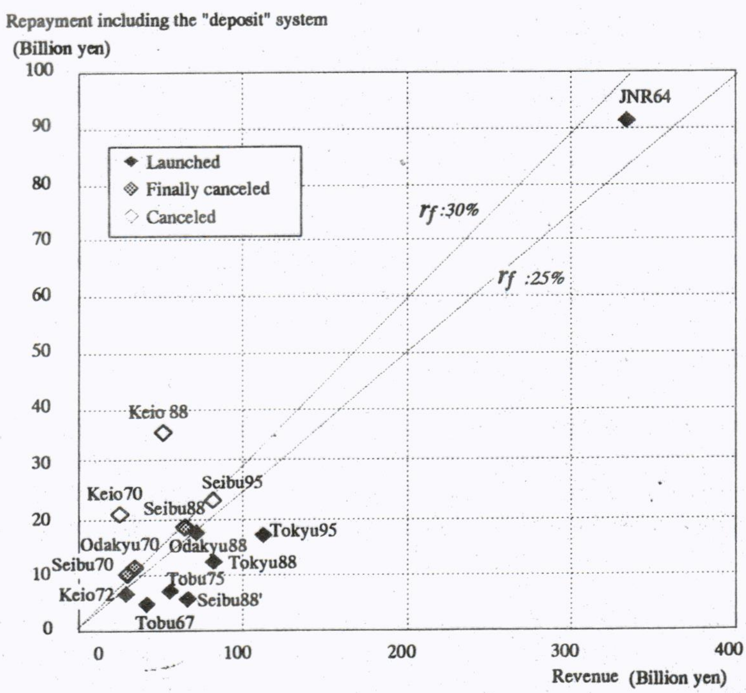

Figure 3. Repayment in opening year and revenue of planning year considering the 'deposit' system (1985 base)

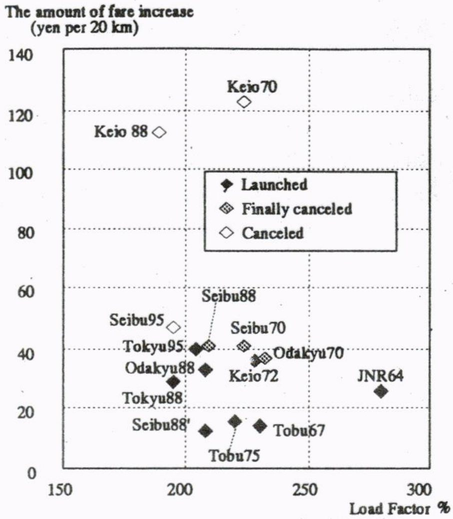

Figure 4. The amount of fare increase (real) and Load Factor

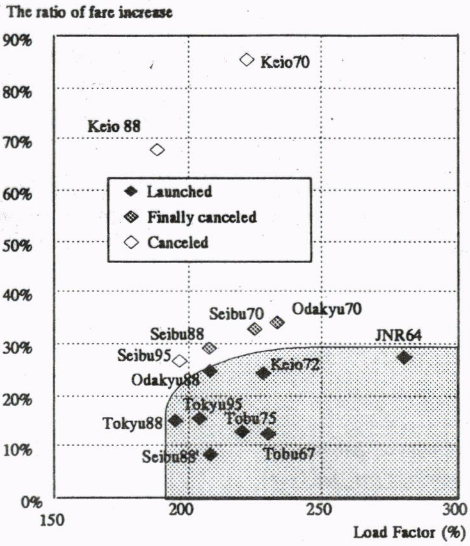

Figure 5. Fare increase ratio and Load Factor

dimensioned by the first pressure and the second pressure. Figure 4 shows the plain of load factor representing the first pressure versus the fare increase representing the second pressure. Unfortunately the separation of 2 groups (launched or not- launched) is not clearly obtained, figure 5, however, is the one substituting the vertical axis for figure 4 by the rate of fare increase. Now these 2 groups are more clearly separated on this plain. The hatched region shows the acceptable region for the operators to launch the project:

1) Maximum rate of fare increase is approximately 25 to 30%.
2) Minimum congestion rate is currently 180%, which may shift to the lower direction in the future.
3) When the load factor is comparative lower, the maximum fare increase is required to get lower.

5.3 The relation between Fare-increase and Fare-level

The fare level is a little different in each railway operator. Here the authors analyze the relation between the fare level and the amount of fare increase (these data are also real). In figure 6 the criterion of the fare increase rate is 25 to 30%. And it may be considered that the higher the rate of fare is, the less rate of fare increase passengers will accept. In the figure 6 the projects are plotted on the plain of fare increase. When we look at the dotted curve which is the border between launched and not-launched projects, the upper mentioned hypothesis is clearly verified:

1) The acceptable rate of fare increase is from 25% to 15% depending on the level of fare.
2) The elasticity of the maximum criterion of the fare increase rate is approximately 0.25 to the rate of fare.

Therefore, the acceptable region for capacity improvement investment will become lower in figure 5, having wider base in the future. It means that passengers will request better service but acceptable range will comparatively be lowered (The effect of income increase in the future is not considered in this prospect).

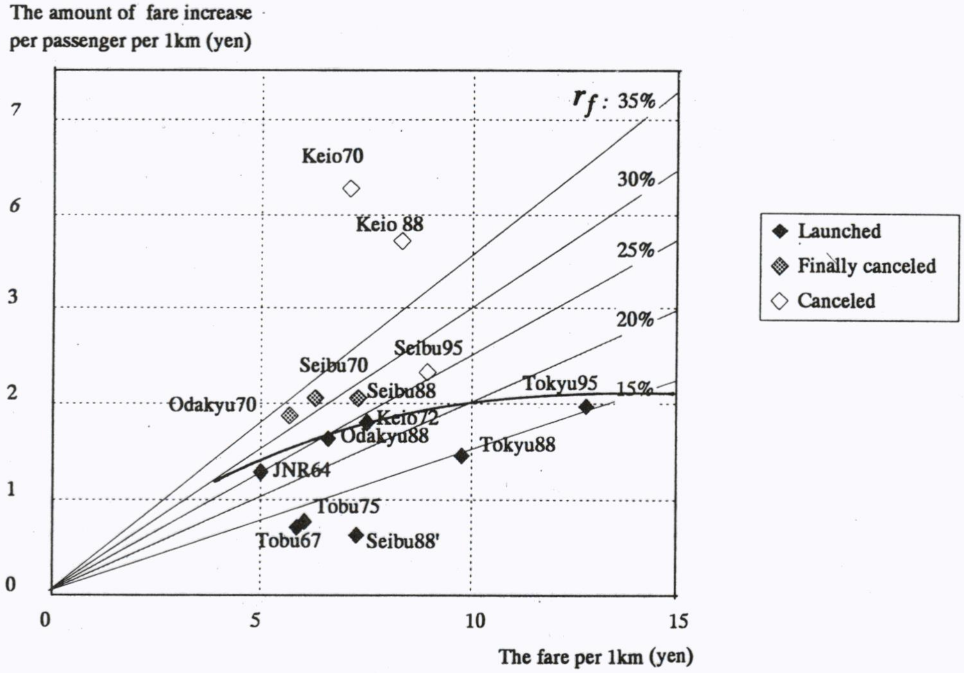

Figure 6. The relation between fare level and fare increase

6. CONCLUSIONS

Followings are concluding points acquired in this study:

1) In Tokyo area, there are many sections which have or will have four tracks. JNR's investment from 1964 was particularly large projects, and most of the private railway companies did not invest to four-tracking projects while JNR did. Private railways began to invest to four-tracking projects after establishment of the 'deposit system'.

2) Whether the operators can launch the large investment or not, can be explained by the 2 types of *social pressure* of passengers onto operators; one can be represented by the level of congestion and the other by the probable fare increase for investment. When the Maximum load factor is less than 190% and the maximum fare increase rate is more than 30%, the operators do not or can not invest to capacity development projects.

3) Passengers respond the maximum fare increase rate at the point of opening time rather than the total fare increase ($RP(t)\ /V(t_1)$). For this reason, the 'deposit' system which makes the increase of fare lower in opening year provides the good incentive for large investment.

4) As the passengers require more comfortable service, the minimum congestion limit whether the projects are launched seems to get reduced year by year. And passengers also respond that the higher the current fare level is, the lower their acceptable maximum rate of fare increase is. Therefore, as the construction cost gets higher by urbanization etc... and fare level gets higher, it will become more difficult to launch four-tracking projects in order to aim further better service level which satisfies passengers.

5) The 'deposit' system plays an important role for realization of large projects. The further efforts should be done to solve the railway congestion problems.

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