POST EVALUATION OF INVESTMENT FOR INCREASING COMMUTER TRANSPORT CAPACITY IN TOKYO METROPOLITAN AREA

Yoshimasa Tadenuma
Research Division
Tokyo Branch Office
Japan Railway Construction Public Corporation
Nishi-Ikebukuro 1-11-1, Toshima-ku, Tokyo,
171-0021, Japan
Fax +81-3-5954-5237
Email: y.tade@jrcc.go.jp

Abstract: This study evaluates how the large-scale project, executed by the former JNR for increasing commuter transport capacity in Tokyo metropolitan area, affected railway users and the financial condition of the company. The project mainly brought two benefits: the reduction of congestion and travel time to the users. The effect of the project is quantified by comparing the "Without Case" in which the project would not be executed with the present situation (the "With Case"). A model is assumed whereby the population distribution in the Tokyo metropolitan area is explained by generalized cost for railway users. By comparing the generalized cost and population distribution between each case, the user benefit of the project and the increase in profit resulting from the project is calculated. As a result of the evaluation, the user benefit is calculated as very large, and the project had a good influence on company revenue.

1.THE BACKGROUND OF THE STUDY

After World War II, population and industry concentrated into the Tokyo metropolitan area in line with Japan's high growth. Working districts in the Tokyo metropolitan area concentrated towards the center of Tokyo, and residential districts spread to the suburbs. Therefore, the commuter transportation volume increased, and in the 1960s, because of the insufficient capacity of railways, which have played a major role in commuter transport, congestion of railway cars became a social problem. In order to ease the congestion, public and private railway companies conducted investment for increasing the transport capacity of their railway lines.

The former JNR (Japanese National Railways) executed investment on a large scale, as a drastic measure to solve the congestion problem, in which the tracks of five radial trunk lines were extended. The length of track extension section was 10 km to 80 km. Under this project, the commuter transportation capacity of these lines drastically increased and commuter congestion was substantially eased. Moreover, in two of these lines, the speed of trains also increased largely because the operation of fast trains was separated with that of local trains by the track extension.

The objective of this study is to evaluate how the project affected railway users and the

financial condition of the company. It is widely recognized that the benefit for users by the project is very large, but as for the profitability, there have been two opinions for the project.

The one is that the project was not profitable and it was one of the causes of the red of JNR (See Appendix 1). Generally, investment for increasing commuter transportation capacity in metropolises in Japan is costly, and it is difficult for such investment to improve the profit of operators for the following reasons. Concerning the commuter transport in these areas in Japan, the modal share of railways is much greater than that of other means of transportation: the rail share for the commuter transportation from the outside of 23 ward to the city center is more than 90%. Therefore, even if the convenience of users is improved by the project, the modal share of railways doesn't expand so much, and the transportation efficiency of the railway may decrease. Even if it is supposed that the number of passengers increases in line with increase of the population of areas along the railway line by track extension, it is difficult to cover the investment cost.

On the other hand, the other opinion is that the project was profitable. The project was implemented at a time when the population of Tokyo was increasing rapidly. If tracks had not been extended in the project, the transportation capacity would have reached a limit, and the commuter transportation of these lines would not have been able to correspond to the increase of transportation demand. Under such a situation, the areas along the railway lines would not have developed like they did, and the transportation volume of these railways would have been smaller than at present. Consequently, it can be said that the project brought about the considerable increase of the number of passengers, and thus contributed to considerable increase of the passenger revenue of the company.

2. OUTLINE OF THE PROJECT

2.1 Planing and the implementation of the project

The section where the project was implemented is shown in figure -1. The project was planned in the 3rd long-term plan of JNR in 1965 and was completed until 1983. The cost of the project is shown in Table -1. The total cost of the project was about 600 billion-yen at net price. This amount includes costs incurred in elevating existing track and exchanging existing rolling stocks. Among the 600 billion-yen, the expenditure for track extension to increase transportation capacity was about 300 billion-yen in net price. In terms of 1995 prices, this cost amounts to about 700 billion-yen, and the cost for track extension per 1km to about 4 billion-yen. The construction cost of railways in the present Tokyo area per 1km is about 20 billion-yen, whereas in the project, track could be extended at a much lower cost than this. The reason why the project was so cheaply executed is because areas along these lines were not yet densely developed and the purchase of land was easier than at present, and the construction method is not so complicated as at present.

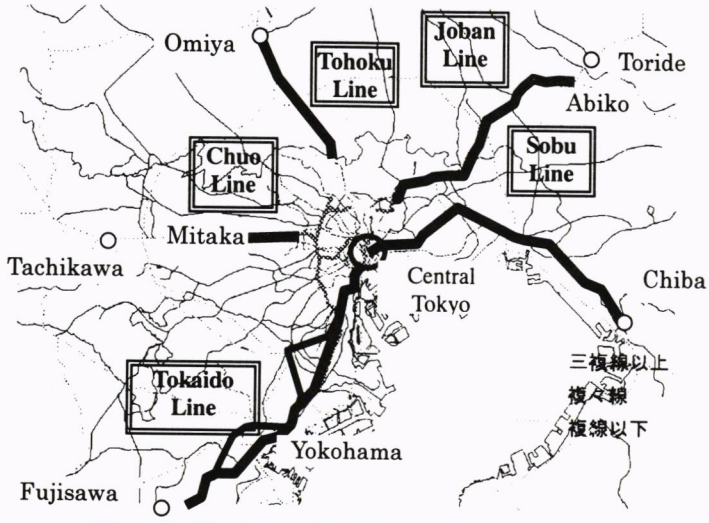

Figure1. The Map of the Project Implemented

The project mainly brought the following two benefits to the users. The first was the ease of congestion by increasing transportation capacity. As shown in Table 2, the transportation capacity of each line was substantially increased by the track extension.

The second was the reduction of travel time. The changes in travel time between the main stations on each line are shown in Table 3. The reduction of travel time was mainly realized by the following two factors. The first point is the operation of fast trains. On the Joban

Table 1:The Cost of the Project (Billion-Yen)

	Length of track extension (km)	Net Price		1995 Price		Cost per 1km (for Infra)
		Infra-structure	Rolling-Stocks	Infra-structure	Rolling-Stocks	
Tokaido Line	77.1	183.9	21.2	348.5	25.0	4.52
Chuo Line	9.4	17.0	4.7	52.2	10.8	5.55
Tohoku Line	17.0	29.3	9.3	78.3	16.8	4.61
Joban Line	30	24.8	13.3	69.9	24.9	2.33
Sobu Line	39.1	62.2	22.2	167.6	36.7	4.29
Total	172.1	317.3	70.7	716.3	114.2	4.15

Table 2. Transport Capacity per Hour before and after the Project
(In peak hour in the most congested section) Unit: thousand/one way

	Before	After
Tokaido Line	53.7	72.2
Chuo Line	42.0	69.4
Tohoku Line	44.0	60.5
Joban Line	22.9	48.4
Sobu Line	33.6	48.0

Table 3. The Travel Time from Suburban City and Tokyo of each Line before and after the Project

	1965	1990
Tokaido Line (from Fujisawa)	1h04m	0h54m
Chuo Line (from Tachikawa)	1h03m	0h58m
Tohoku Line (from Omiya)	0h35m	0h29m
Joban Line (from Toride)	0h57m	0h42m
Sobu Line (from Chiba)	1h01m	0h40m

See Figure 1., in order to understand the location of the above city

Line and the Sobu Line, fast trains have been operated since the completion of the project. The added tracks on these lines were exclusively used for fast trains. The timetables of fast trains are set independently from local trains. If the tracks had not been extended, such reduction of travel time due to the operation of fast trains would have been difficult. The second point is the reduction of station stop time, especially that at terminal stations, brought about by congestion reduction. Moreover, train delay in peak hours was largely decreased, which led to the reduction of actual travel time.

2.2 Expansion of the Tokyo metropolitan area and increase of the number of passengers

During and after the project, industry and population in the Tokyo area have grown through the high growth of Japan and population has become suburbanized (see Appendix 2). It is likely that the project had some influence on suburbanization. The improvement in the convenience of these lines (eased congestion and reduced travel time) brought about by the project led to the expansion of commuter residential areas. Moreover, it is possible to say that the enormous number of the present commuters could not have been physically transported without the increase in transportation capacity brought about by the project. Here, the congestion rate (Note 1), based on the transportation capacity in the case of no project implementation and the current transportation volume, is estimated as shown in Table 4. On each line, all of the series of estimated congestion rates are higher than those in the present situation, and the congestion rate on some lines is more than 400%. Actually, a congestion rate of 400% isn't realistic, and it is likely that many of the passengers who want to take trains in peak hours would take trains before and after the peak hours. The distribution of the population in areas along railway lines may have been different from the present situation, and the whole transportation volume would be smaller than at present. However, congestion far more intense than at present would have occurred, and it is assumed that the following serious situation would have arisen.

- Passengers unable to board trains would overflow in stations.
- Entry to stations would be limited due to crowded platforms.

Table 4. The Estimated Congestion Rate in the Case of no Project Implementation.

	Present	No Project Implementation
Tokaido Line	250%	346%
Chuo Line	172%	286%
Tohoku Line	215%	297%
Joban Line	238%	477%
Sobu Line	237%	442%

- Trains would be delayed because of difficulty in opening and closing doors of train.

On the other hand, it is pointed out as a problem that suburbanization has proceeded disorderedly, and working areas have been separated from the residential areas. As a result, the average commuting travel time has increased.

3 POST-EVALUATION OF THE PROJECT INVESTMENT EFFECT

Previously, a lot of post-evaluation has been conducted on the effect of investment intended to increase commuting transportation capacity in the Tokyo area. For the project, the metropolitan area headquarters of JNR, which executed the project itself, evaluated the effect of the project in 1982 after completion of the project. In the evaluation, change of revenue and expenditure by the project was estimated for the period from 1965 to 2010. The influence of the project on the location of residence and industry in Tokyo was analyzed by using data from 1960 to 1978, including the residential population and the working population. But, it is possible to point to the following problems in this post-evaluation.

- The number of passengers which was increased by the track extension is supposed as the difference of the present number of passengers and the maximum transportation capacity (240%). However, the congestion rate had already exceeded 240% on a lot of lines before the project. Therefore, it is likely that the increase in profit was overestimated.
- This evaluation deals only with the operating balance of the company and makes no attempt to quantify the social effect.
- In this evaluation, the residential population and working population of areas along a railway line in the case of no project implementation are estimated. However, this isn't reflected in the transportation volume used in calculating the revenue and expenditure balance.

4. CALCULATION OF THE USER BENEFIT AND THE INVESTMENT PROFIT

4.1 Preconditions for the evaluation

The project effect is quantified based on the following presuppositions.

- The effect of the project is quantified by comparing the "Without Case" in which the project would not be executed with the present situation (the "With Case").
- The evaluation assumes that the population distribution over the Tokyo area was influenced by the project. Therefore, a model is assumed whereby the population distribution in the Tokyo metropolitan area is explained by generalized cost (Note 2) for railway users from each city to the working areas.
- The target year for comparison is 1995, and the effect is evaluated based on the business condition of the present JR. Labor productivity in the JNR era was worse than that of the present JR which was the major cause of JNR's management failure. Therefore, it is possible to say that evaluation based on the business condition of JNR is improper for measuring the effect of the facilities.
- The effect which the project brought to the growth of Tokyo isn't considered. That is, it is supposed that the total population of Tokyo in the "With Case" is the same as that in the "Without Case".

- The data of the number of passengers of each section between stations are those in case of all day and the morning peak of the metropolitan traffic census.
- The transportation capacity in the "Without Case" is generally assumed to be the same as that for local trains running on one pair of the double tracks of the quadruple tracks in the "With Case". Table -5 shows the train frequency and transportation capacity on each line in the "With Case" and the "Without Case". The travel time in the "Without Case" is the same as the local trains in the "With Case". Delay of trains caused by intense congestion is not taken into consideration.
- The fare in the "Without Case" is same as the fare in the "With Case", because the determination of fare was not related to the project. The current railway fare of JR was determined rather under price regulation. However revenue from fare was not too small to fill the cost of JNR, including running cost, interest and depreciation cost. The government have not controlled the profits of JNR, but the government (or parliament) controlled the fare with reference of the price on the other goods. Moreover even if assuming that the fare is determined under the balance between revenue and expenditure, the balance is one for the finance of whole JNR which includes the Shinkansen, and other local lines.
- The modal share of road transportation and railway transportation in the "Without Case" is same as that in the "With Case". The present modal share of railways from the areas outside of the 23 inner wards of Tokyo 23 to the said 23 wards is more than 90%. Therefore, when supposing that this function for modal share was expressed as the logistic

Table 5. Frequency and Transportation Capacity on each Line in each Case On Peak Hour

(Frequency : train number/one hour:one way Transport Capacity : Person/one hour oneway)

	With		Without	
	Frequency	Transport Capacity	Frequency	Transport Capacity
Tokaido Line Fast train	19	29,600	12	18,700
Local train	11	17,200	7	10,900
Total		46,800		29,600
Chuo Line Fast train	27	37,800	27	37,800
Local train	23	32,200	-	-
Total		60,000		37,800
Tohoku Line Fast train	23	41,400	12	21,600
Local train	24	33,600	24	33,600
Total		75,000		55,200
Joban Line Fast train	18	36,500	-	-
Local train	22	30,800	24	37,000
Total		67,300		37,000
Sobu Line Fast train	17	27,600		
Local train	24	33,600	24	33,600
Total		61,200		33,600

curve, the increase of the generalized cost by more intensive congestion and slow train speed would not have a big influence on the modal share of the railway.

4.2 The flow of effect quantification

The effect of the project is quantified according to the flow shown in Figure 2. In the primary step, congestion and travel time in the "Without Case" is estimated. By merging these together, the generalized cost for railway users is calculated. In the second step, a model of population distribution in the Tokyo area, in which generalized cost is a variable, is made. By putting the generalized cost in the "Without Case" into the model, the population distribution in the "Without Case" is estimated. In the third step, based on the population distribution in the "Without Case" which was calculated in the second-stage, the number of passengers using each line in the "Without Case" is estimated. The number of passengers calculated is used for the second calculation for the flow. After the number of passenger converges through the series of calculation, the user benefit of the project is calculated, by comparing with the "With Case" based on the generalized cost and the number of passengers in the "Without Case". Based on the calculated number of passengers in "Without Case", the increase in profit resulting from the project is calculated.

4.2.1 Calculation of the generalized cost for railway users

First, a series of the generalized cost for users from each city along railway lines to the main working areas is calculated for each case. The calculation of generalized cost dealt with peak hours in the morning. Some stations exist in each city, and in this study a representative station is set for each city, based on the number of the passengers and the location of each station. Then, the generalized cost from the station to the main working areas is calculated. By using formula -1, fare, travel time and congestion rate are converted to the generalized cost.

$$GC = C + d(T+F) \qquad (1)$$

GC : Generalized cost (Yen)

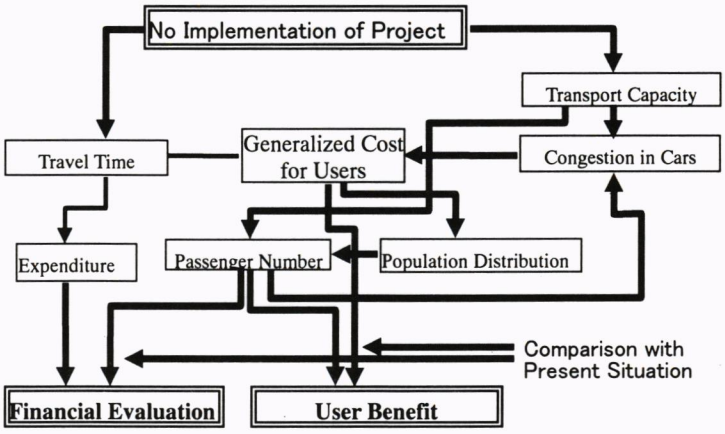

Figure 2. The Flow for Quantifying the Effect of the Project

C : Fare (Yen)
T : Travel time (during rush hour: minutes)
F : Congestion disutility (expressed in minutes)
d : Time value (Yen/ minute)
= 38 yen (From investigation of monthly work statistics in 1995)

Some functions to convert congestion to the travel time here are defined. In this study, the following formula which was estimated at "the great city traffic census analysis volume" in 1990 is used, because this study used the census data.

$$F=0.00739\times CR^{3.8}\times T \qquad (2)$$

CR : Congestion rate

Here, in the process of quantification in this study, the congestion rate from 400% to 500% which cannot exist physically is often calculated. On the other hand, formula -2 is the function which was found from the congestion rate in the present situation. Therefore, it would be improper to put the congestion rate directly into formula -2. In this study, the maximum congestion rate is regarded as 300%. It is assumed that overflowing passengers get on train 1 hour before the peak hour, that is, it is assumed the arriving time at office is fixed and passenger who could not take the train would have to take earlier train which congestion rate of less than 300%.

By using formula -1 and formula -2, the generalized cost that excluded fare, based on the travel time and the congestion rate between each station of each railway line, is calculated. Based on it, generalized cost from the representative station in each city to the station in the main working areas is calculated. Figure -4 compares the generalized cost for each case. On each line, the generalized cost by the congestion in the "Without Case" is large compared with that in the "With Case". On the Joban line and the Sobu line, the generalized cost in the

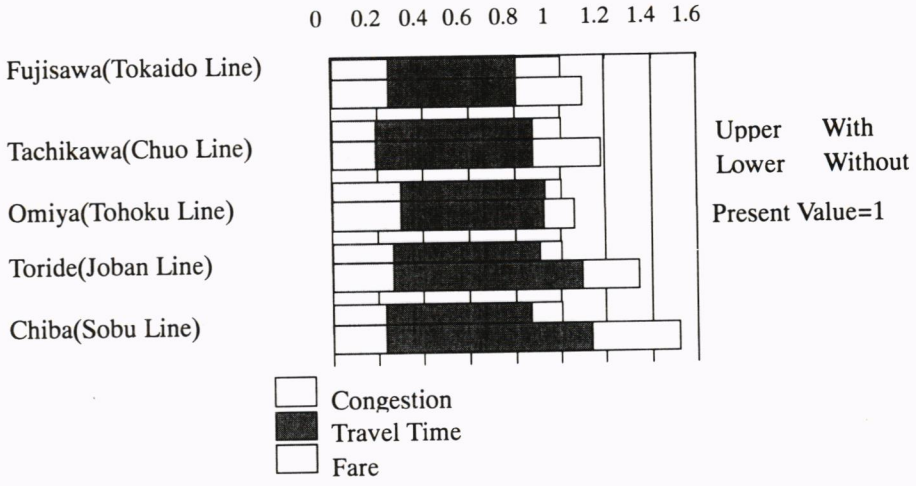

Figure 3: The Comparison of Generalized Cost of each Case
(to Tokyo Station in peak hour)

"Without Case" where fast trains aren't operated becomes about 30-50% larger than in the "With Case", because fast trains have been operated on these lines since track extension.

4.2.2 Calculation of population distribution

When estimating population distribution in the "Without Case", a regression formula is estimated, in which the population of each city is explained by the generalized cost from each city to main working areas. By putting generalized cost in the "Without Case" into this formula, population distribution by the "Without Case" is estimated. To express the distribution of resident population, a lot of model formulas such as Colin Clark's density function formula were made. In this study, the following resident choice function was supposed and parameters were estimated. Some main terminal stations which are in the main working area in the Tokyo area are selected and, by using generalized cost in the "With Case" from the representative station in each city to terminal stations, a model formula is made. Upon retaining variables considered to be significant, the following formula was made.

$$p_i = e^{V_i} / \sum_k^n e^{V_k}$$

$$V_k = a_1 \times GC_{\text{Tokyo, k}} + a_2 \times GC_{\text{Yokohama, k}} + a_3 \times log(S_k) \qquad (3)$$

where:

$p_i = P_i / P_{total}$

P_i : Urban residential population (i) (persons)

P_{total} : Total population of Tokyo (persons)

(From the habitant basis ledger population summary (the Ministry of Home Affairs, Administration Bureau))

$GC_{Tokyo, i}$: The generalized cost from city (i) to Tokyo (Yen)

$GC_{\text{Yokohama, i}}$: The generalized cost from city (i) to Yokohama (Yen)

S_i : The area of city (i) (km^2)

The samples are 173 cities along railways in the Tokyo metropolitan area. Four wards in the center of Tokyo are excluded from the samples, because, in these areas, the working areas occupy most of the land and residential land is small, and it is assumed that population values in these four wards would make model precision low. The following table shows the parameter estimation results and the coefficient determined upon conducting adjustment of the degree of freedom.

a_1	-4.4×10^{-4} (-120.3)
a_2	-1.2×10^{-4} (-51.2)
a_3	7.3×10^{1} (147.9)

* The coefficient in parenthesizes is t value.

*The decision coefficient after adjusting for the degree of freedom is 0.759

Generalized cost from each city to the terminal station in the "Without Case" is put into formula -3 and the population of each city in the "Without Case" is calculated. The results of the calculation of the population of some cities along the lines in the "Without Case" are shown in Table 6. As compared with the "With Case", the residential population in the Tokyo area would not spread to the suburbs in the "Without Case". The population of cities

Table 6. The Estimated Population of Some Cities along the Lines in the "Without Case"

	Population(Thousand)		Without / With -1
	With	Without	
Fujisawa	369	294	-20.3
Tachikawa	158	153	-2.8
Omiya	433	398	-8.2
Toride	85	56	-33.3
Chiba	856	509	-40.6
Bunkyo (City Center)	172	194	12.7

along these lines would remain at the level of 10-20 years before.

4.2.3 The calculation of the number of passengers

The number of passengers of each section between station is estimated under the following assumption based on the number of passengers taking trains and getting off trains at each station quoted from "The Urban Transport Yearbook".

- The number of passengers taking trains at a station is proportional to the residential population of the city where the station is located.
- The number of the passengers getting off trains at a station is proportional to the number of passengers between the station and the next station on the suburban side.

Based on the above-mentioned assumptions, formula-3 can be defined for calculating the number of passengers in the "Without Case".

$$PN_n = PN_{n-1} + \frac{PD_n}{PD'_n}(PN'_n - PN'_{n-1}) \times \frac{Po_n}{Po_n + Pd_n} \qquad (3)$$

Where:

PN_n : the number of passengers between station n+1 and station n in the "Without Case"
PN'_n the number of passengers between station n+1-station n in the"With Case"
PD_n Population density (Without) of the city where the station n is located
PD'_n : Population density (With) of the city where the station n is located
Po_n: Number of passengers taking trains at the station n (With)
Pd_n : Number of passengers getting off trains at the station n (With)
(From the Urban Transportation Yearbook)

The passenger number calculated in the above formula is reflected to the calculation of the generalized cost for users.

4.3 Estimation of the user benefit

4.3.1 Preconditions

A user benefit between each station is computed by taking a shortcut formula (Note 3) from the number of passengers among each station and the generalization expense between each station of each case, and it is totaled for each direction of the improved line. The effect of the congestion reduction on only the up trains in the peak hour is considered, but congestion in the

evening rushes in other time zones is not considered. This is because the reduction of the generalized cost for the congestion by these time zones was small compared with the time of the peak in the morning. Only the effect of the reduction of travel time which was achieved by the operation of fast trains is taken into consideration. On the other hand, the effect of the time reduction which accompanies the improvement of rolling stock technology, and the effect of reduced delays in line with congestion relaxation, aren't taken into consideration. The time reduction effect can be appropriated all day.

4.3.2 The result of estimation

Under such a presupposition, the user benefit which was calculated for each line where the project was executed is shown in Table 7. The user benefit of the project was estimated as about 190 billion-yen for 1 year. The economic internal rate of return when calculating for the period of 30 years after completion of the project is 17.6%. The user benefit generated by congestion relaxation is 90 billion-yen and the benefit from reduction of travel time is 100 billion-yen. The main purpose of the project was to increase transportation capacity in order to ease congestion. However, according to the result of the calculation, the user benefit from the ease of congestion is smaller than the user benefit from the reduction of travel time. This is mainly because the number of passengers in the "Without Case" would be smaller than in the "With Case" since the population would not have spread to the suburbs when the congestion would be more intense.

When seeing each line, the user benefit of the Joban line and the Sobu line is very large. There are two main reasons for this:

- The operation of high-speed trains was started by track extension and the effect of the reduction of travel time is very large.
- The transportation capacity was doubled as a result of track extension. The number of passengers is well distributed in local trains and fast trains and the congestion relaxation effect is also very large.

Concerning the other lines, too, the user benefit from congestion reduction is large.

4.4 Financial evaluation

4.4.1 Revenue

To calculate the revenue, the important element is the fare level. In this study, the fare level is set as shown in Table 8.

Table 7:The Estimated User Benefit of the Project
(billion-yen per year: 1995 price)

	Total	Congestion Reduction	Reduction of travel Time	Economic Internal Rate of Return
Tokaido Line	20.7	20.7	0	
Chuo Line	13.5	13.5	0	
Tohoku Line	12.2	12.2	0	
Joban Line	79.8	24.6	55.2	
Sobu Line	67.5	20.1	47.4	
Total	193.7	91.2	102.5	18.3%

Table 8.The Set of Fare Rate

	Total of JR East		In Tokyo	
	Commuter Ticket	Ordinary Ticket	Commuter Ticket	Ordinary Ticket
Passenger-km (Million/year)	74,896 ①	53,702 ④	64,194 ⑦	26,015 ⑧
Passenger Revenue (Million-yen/year)	499 ②	1,212 ⑤		
Fare Rate (Yen)	6.7 ③	22.6 ⑥	-	-
Average Fare Rate (Yen)			**11.2** $\frac{③\times⑦+⑥\times⑧}{(⑦+⑧)}$	

4.4.2 Expenditure

To calculate expenditure, the cost unit is necessary. At present, cost units for each JR line are not published. The cost unit of each JR Company is published by the Ministry of Transport. When calculating these values, local lines with small transportation density are also taken into consideration, and if using this cost unit, calculated expenditure is larger than actual expenditure. In this evaluation, the cost unit in major urban private railways is used because transportation density of these railways is similar to that of the five lines.

4.4.3 Results of the evaluation

Table -9 shows the financial evaluation for each line of the project. The increase in profit resulting from the project is about 90 billion-yen per year and the financial internal rate of return in 30 years is 10.8%. This value becomes a very high compared with the standard discount rate of the benefit which is shown in the cost-benefit manual at present.

When seeing each line, the increase of the profit of the Sobu Line and the Joban Line, in which the generalized cost was largely reduced, and the Tokaido Line, in which the number of passengers is large, reaches 100 to 200 billion-yen per year. In these lines, the generalized cost for users largely decreased, and therefore, there is likely to be much population of the areas along these lines in the "With Case" as compared to the "Without Case". On the other hand, as for the Chuo Line, the increase of profit is small compared with the other railways,

Table 9.Revenue and Expenditure in each Case
(Billion-yen per year:1995 price)

	Operation Revenue		Operation Expenditure		Operation profit (before depreciation)			FIRR
	With	Without	With	Without	With	Without	Difference	
Tokaido Line	2,231	1,933	647	541	1,584	1,392	192	
Chuo Line	1,297	1,229	470	443	827	786	41	
Tohoku Line	1,639	1,430	563	483	1,075	947	128	
Joban Line	1,198	807	494	394	703	413	290	
Sobu Line	1,148	719	422	305	726	413	312	
Total	7,512	6,118	2,597	2,167	4,915	3,951	964	10.8%

because there is not a big difference in the population of the areas along the line and in the number of passengers between two cases. But, still, the financial internal rate of return on the Chuo Line exceeds 4%. Incidentally, when considering this calculation flow, it is clear that the increase in revenue was brought about by the congestion relaxation of each railway resulting from the project. Therefore, we can say that the congestion relaxation effect of the project was very large.

5.CONCLUSION

This study evaluated the large-scale investment of JNR among past investment conducted with the aim of increasing commuting transportation capacity. As a result of the evaluation, the user benefit which was brought about by the project is calculated as very large, and the project had a good influence on company revenue. The user benefit from the reduction of travel time is larger than the user benefit from congestion relaxation. However, it is possible to say that most of the increase of revenue of JR was brought about by congestion relaxation.

In general, the investment for commuting transportation capacity in the metropolitan area did not bring about increase in the number of passengers, but this occurred as a result of population increase along the lines in the short run. Therefore, such investment is not profitable in the short run. However, it was shown in this study not only that the project for increasing commuting transportation capacity improves the convenience of the railway users, but also that in the process that the metropolitan area is growing, the project contributes to the railway business.

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APPENDIX

Appendix 1:

When this project was done, JNR was conducting other big investments in addition to this project. Investment in those days, including this project, is sometimes criticized for being too large. Due to its constant operation in the red, the management of JNR failed and it was privatized in 1987. Concerning the reasons why JNR went into the red, the following three have been pointed out as the major factors.

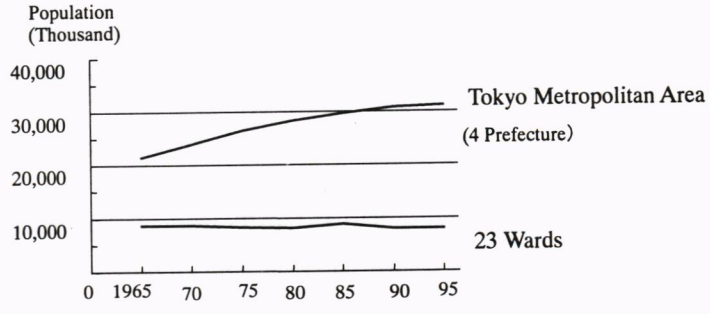
1) Because motorization had developed since the 1950s, the freight volume of JNR decreased and the number of passengers stagnated.

2) Although the organization of JNR was inefficient, JNR was slow to advance rationalization, and therefore the expenditure increased.

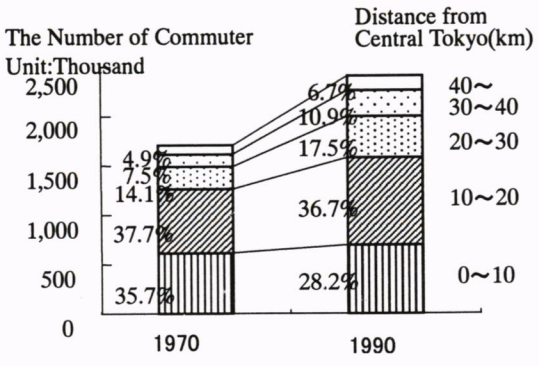
3) It was difficult for JNR to avoid external interference from the government and Diet, and railway investment sometimes executed without a viewpoint of there profitability but with a viewpoint of political matters.

Appendix 2:

Attached chart -1 shows population change in the Tokyo area (city and 3 prefectures) and 23 wards between 1965 and 1995. During this period, the population of the Tokyo area increased by about 40 percent whereas the population of the 23 wards decreased. This shows that suburbanization has progressed with the expansion of the Tokyo area since 1965. On the other hand, the working population of the central part has increased over the same period. In attached chart -2, the number of commuters to the central part (four downtown wards) in 1970 and in 1990 is classified according to the distance. The number of commuters to the central part increased by about 40 percent between 1970 and 1990. On the other hand, in 1970, 73%



Attached Figure 1 Population Change in the Tokyo Area and 23 wards



Attached chart 2: The Number of Commuters to the Central Part (four downtown wards)

of commuters to the central part were residents living within 20 km of the downtown area, but in 1990, this had decreased to 65%. During this period, both the quantity and the ratio of long-distance commuters increased largely

NOTE

[Note 1] Congestion rate is expressed by the following formula.
Congestion rate = number of passengers in a train / passenger capacity of the train
The passenger volume to say here is not the number of the seats but the value obtained by dividing the area of the train car by the area per passenger.
[Note 2] The generalized cost is the combined cash value of the disutility for users such as the travel time, number of train transfers and, congestion rate
(From the expense of the railway project vs. effect analysis manual 97, P16)
[Note 3] The shortcut formula is one of the calculation methods of the user benefit brought by the improvement of traffic service. The shaded area of the following figure is expressed as the user benefit.

(A detailed description of this is given in "Evaluation of the Benefit of Infrastructure Construction" by Morisugi [1997],).