A Before-After Comparison of Productivity Growth

— The Case of JR — *

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1. Introduction

A most distinctive feature of the Japanese rail industry is that privately owned railways play a very important role in urban commuter service without government subsidies. Since the Japan National Railways (JNR hereafter) was privatized and regionally broken up into six regional passenger railway companies (JR Passenger hereafter) and one nationwide freight railway company (JR Freight hereafter) in 1987, there have been no national railways in Japan. However, strictly speaking, because the national government still holds some equity in JRs, JRs are not as completely privatized as other Japanese private railways, although they are to be so in the future.

JNR was privatized mainly because JNR incurred a serious government deficit. Moreover, rail users severely criticized the deterioration in service quality of JNR. Since private railways are generally recognized to be more efficient and have a better reputation of efficiently supplying quality of service than the public sector, it was natural for policy makers and academicians as well as the public to believe that privatization was a necessary step to rationalize the management of JNR.

Since the privatization of JNR, JRs' service performance has improved dramatically. There is no doubt that the privatization of the JNR will turn out to be successful, although problems will not entirely disappear. Of several important aspects, this paper focuses on the quantitative analysis of labor

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TABLE 1 Labor Productivity Comparison between JR and Large Private

	passenger−km per employee (thousand)		car−km per employee (thousand)		train−km peremployee (thousand)	
year	JR	Large Private	JR	Large Private	JR	Large Private
1981	509 (0.30)	1693 (1.00)	11.7 (0.45)	25.8 (1.00)	1.36 (0.27)	5.05 (1.00)
1982	524 (0.31)	1710 (1.00)	12.0 (0.46)	26.1 (1.00)	1.41 (0.28)	5.07 (1.00)
1983	573 (0.33)	1738 (1.00)	12.8 (0.48)	26.5 (1.00)	1.52 (0.30)	5.08 (1.00)
1984	633 (0.36)	1751 (1.00)	13.6 (0.50)	27.2 (1.00)	1.68 (0.33)	5.13 (1.00)
1985	758 (0.42)	1793 (1.00)	15.7 (0.57)	27.6 (1.00)	2.02 (0.39)	5.15 (1.00)
1986	929 (0.51)	1837 (1.00)	19.4 (0.70)	28.1 (1.00)	2.56 (0.50)	5.15 (1.00)
1987	1134 (0.61)	1863 (1.00)	22.3 (0.79)	28.2 (1.00)	3.06 (0.60)	5.12 (1.00)
1988	1281 (0.67)	1922 (1.00)	25.0 (0.89)	29.3 (1.00)	3.55 (0.68)	5.25 (1.00)
1989	1359 (0.70)	1939 (1.00)	27.8 (0.92)	30.2 (1.00)	3.86 (0.73)	5.30 (1.00)
1990	1496 (0.75)	1985 (1.00)	29.6 (0.98)	31.1 (1.00)	4.11 (0.79)	5.19 (1.00)
1991	1558 (0.77)	2019 (1.00)	30.0 (0.94)	31.9 (1.00)	4.22 (0.78)	5.41 (1.00)
% change (1981−85)	48.9%	5.9%	34.2%	7.0%	48.5%	2.0%
% change (1985−89)	79.3%	8.1%	77.1%	9.4%	91.1%	2.9%
% change (1987−91)	37.4%	8.4%	34.5%	13.1%	37.9%	5.7%

(Note):
1) The number in parentheses is the ratio of the passenger of JRs to that for the large private railways.
2) The number in labor productivity is only passenger JRs.

productivity of JR railways, partly because there is no econometric research on this matter and partly because labor is the most significant factor which affects efficiency and cost structure in such a labor intensive industry as the rail industry.

We address the following questions. First, why and how much has productivity increased since privatization? A comparative study with Japanese private railways is implemented. One interesting question is when productivity growth began; did it occur after or during the process of privatization? And we also investigate how fast JR has cut its work force. Second, how different is productivity expansion among activities? If it is true that privatization has contributed to productivity growth, then what kind of activity is relatively easier to improve? Third, is the existing employment level of JRs too low compared with other private railways ?

2. Analysis of Labor Productivity Growth

2.1. Labor Productivity Growth

There is no doubt that privatization has been increasing productivity in JRs. Here we will see how much productivity has increased, what kind of locus of productivity growth showed (i.e. whether productivity growth began after privatization or started several years before), and whether the productivity level of JRs has already reached the level of Japanese large private railways, which are considered the most efficient organizations in the rail industry. As a measure of productivity we used three kinds of labor productivity by the difference of service outputs (i.e. passenger−km, car−km, and train−km per year). The definition of labor productivity used here is service output per employee. Table 1 shows the change in productivity from 1981 to 1991.

Labor productivity has increased dramatically since privatization of JNR in any kind of measurement: passenger−km, car−km, or train−km per employee (see Table 1). In fact, productivity figures of JRs show a threefold growth from only 509 thousand passenger−km per employee in 1981 to 1, 558 thousand passenger−km in 1991. Compared with 20% of productivity

TABLE 2 Estimation of Employment Adjustment Speed

case	case−1	case−2	case−3	case−4
sample group	JR	JR	JR	private
type of sample case	after privatization (1987−91)	during privatization (1985−88)	before privatization (1981−84)	1981−91
employment adjustment speed	0.452 (1.16)	0.928 (2.39)	0.378 (0.97)	0.388 (1.00)

(Note):
(1) JR's employment adjustment speed (λ) is an average of each time period. An estimation of λ is obtained by the following model.
$\ln (EMP_T) = \lambda^* \ln (EMP_T^*) + (1-\lambda)^* \ln (EMP_{T-1})$
where EMP_T = total employees in year T
EMP_{T-1} = total employees in year T−1
EMP_T^* = expected employees in year T
(assuming 85% of employees in year T−1)
λ = employment adjustment speed
(2) The estimation of private's employment adjustment speed is used by regression equation as follows:
$\ln (EMP_T) = \alpha + \beta^* \ln (EMP_{T-1})$
where $\alpha = \lambda^* \ln (EMP^*)$ (EMP^* is unknown)
$\beta = 1-\lambda$
(3) JR (total of 6 passenger JR railways), private (total of large private railways)
(4) The number in parentheses is the ratio to the number for private railways.

growth of large private railways during the same period, JRs' productivity growth rate is surprisingly high. Certainly privatization could be responsible for high productivity growth.

However, the productivity level of JRs is still lower than that of large private railways, although it has increased sharply since the mid−80s. Statistics shown in Table 1 do not control for any difference between the two sectors such as network conditions, but the productivity of JRs is still about 23% in passenger−km, 6% in car−km, and 22% in train−km per employee lower than large private railways.

2.2. Employment Adjustment Speed

The locus of productivity growth of JRs has fluctuated in waves. It is interesting to see the fact that high productivity growth started several years before privatization in 1987 and moreover, the growth rate during the time when privatization was discussed was higher than that after

privatization. For example, the JRs' growth rate of productivity during the five years from 1985 to 1989 was 79.3% in passenger−km, 77.1% in car−km, and 91.1% in train−km per employee, but in the after−privatization period (from 1987 to 1991) the figures were 37.4%, 34.5%, and 37.9% respectively. Such a high productivity growth during the several years before privatization could be attributed to the announcement effect on management as well as workers that JNR would soon be privatized. The announcement provided the anti−privatization side with motivation to improve productivity in order to show that privatization was not necessary. For the pro−privatization side, it encouraged them to make efforts to increase productivity. Since the management expected privatization to free them from regulation and make their railways comparable to large private railways, they felt motivated to make many organizational reforms for future management.

To assess the announcement effect of privatization on productivity growth, we will analyze how fast JRs have adjusted their employees by applying the traditional employment adjustment function. The function is adopted in which actual employment adjusts when it deviates from its expected level. In the following adjustment equation EMP* stands for the optimal employment level under given output and technology. If the actual employment level at some point of time deviates from the optimal level, the company tries to reduce its employees to attain the expected level (EMP*). EMP* varies over time because the reduction cost of employees sometimes may be high. The employment adjustment function is often shown as follows:[1]

$$(EMP_T / EMP_{T-1}) = (EMP_T^* / EMP_{T-1})\,\lambda \qquad (1)$$

where EMP_T = employees in year T

EMP_{T-1} = employees in year T−1

EMP_T^* = expected employees in year T

λ = employment adjustment speed $(0 < \lambda < 1)$

By taking the natural logarithm the equation above can be rewritten as follows:

$$\ln (EMP_T) = \lambda^* \ln (EMP_T^*) + (1-\lambda)^* \ln (EMP_{T-1}) \qquad (2)$$

The employment level (or productivity level) of a railway company depends on network conditions and service output level. However, if a railway has not drastically changed them in a short period of time, it could be possible to adopt the model shown in the equation (1) or (2). The coefficient λ represents the speed of employment adjustment. If λ is close to one, it means that the company is very flexible in adjusting its employment to the optimum level. Table 2 shows the estimated employment adjustment speed of JRs using the equation.

In this estimation, we assume that the expected employees in year T (EMP_T^*) is 85.33% of employees in year T−1.[2] Table 2 shows the employment adjustment speed for three different periods: after privatization, during privatization, and before privatization. On the other hand, since it is difficult to specify the expected level of the private's employees in year T (EMP_T^*), we consider that the expected employees is constant over time (EMP^*) rather than variable over time (EMP_T^*). And we estimate private's employment adjustment speed by regression. The results indicate that the employment adjustment speed during the privatization period (1985−88) is 0.928, which is not only the highest in the estimation but also about twice as much as for private railways. In contrast with this, the adjustment speed before the privatization period (1981−84) is almost 0.378, which is comparable with large private railways. The evidence suggests that JNR was not keen on reducing employees even though it was clearly overemployed. Although the speed after privatization (1987−91) is still higher than private railways by 16%, it is not as high as during the privatization period.

2.3. Labor Productivity by Activity Difference

In this section, we will analyze labor productivity by activity differ-

TABLE 3 Proportion of Employees and Productivity by Activity Difference

(A) proportion of employees by activity		year			% change		
		1981	1985	1991	81-85	85-89	87-91
EMPo (operators & conductors)	JR	12.6% (0.50)	16.2% (0.63)	21.3% (0.79)	10.2%	27.8%	6.0%
	private	25.1% (1.00)	25.6% (1.00)	26.9% (1.00)	2.0%	3.9%	3.9%
EMPs (station employees)	JR	41.9% (1.23)	38.3% (1.14)	32.8% (0.96)	-8.6%	-13.1%	-7.6%
	private	34.0% (1.00)	33.6% (1.00)	34.2% (1.00)	-1.2%	0.3%	1.8%
EMPt (track maintenance employees)	JR	14.6% (1.00)	15.8% (1.09)	17.9% (1.31)	8.2%	23.4%	-13.1%
	private	14.6% (1.00)	14.5% (1.00)	13.7% (1.00)	-0.7%	-2.8%	-3.5%
EMPr (car maintenance employees)	JR	18.4% (1.59)	15.1% (1.35)	8.8% (0.87)	-17.9%	-41.7%	2.3%
	private	11.6% (1.00)	11.2% (1.00)	10.1% (1.00)	-3.4%	-8.9%	-6.5%
EMPh (administration & engineering employees)	JR	12.5% (0.84)	14.6% (0.95)	19.2% (1.27)	16.8%	21.9%	8.3%
	private	14.8% (1.00)	15.3% (1.00)	15.1% (1.00)	3.4%	0.0%	-3.2%
(B) productivity by activity difference		year			% change		
		1981	1985	1991	81-85	85-89	87-91
PRDo (operator & conductor)	JR	4,043 (0.60)	4,689 (0.67)	6,864 (0.91)	16.0%	31.8%	29.5%
	private	6,750 (1.00)	7,016 (1.00)	7,504 (1.00)	3.9%	4.1%	4.2%
PRDs (station)	JR	1,214 (0.24)	1,979 (0.37)	4,465 (0.76)	63.0%	93.9%	48.4%
	private	4,981 (1.00)	5,343 (1.00)	5,899 (1.00)	7.3%	7.6%	6.5%
PRDt (track maintenance)	JR	3,486 (0.30)	4,800 (0.39)	8,153 (0.55)	37.7%	36.2%	57.3%
	private	11,627 (1.00)	12,395 (1.00)	14,727 (1.00)	6.6%	10.6%	11.8%
PRDr (car maintenance)	JR	2,761 (0.19)	5,016 (0.31)	16,644 (0.83)	81.7%	189.5%	33.8%
	private	14,640 (1.00)	16,058 (1.00)	20,044 (1.00)	9.7%	17.9%	15.7%
PRDh (administration & engineering)	JR	4,079 (0.36)	5,203 (0.44)	7,622 (0.57)	27.6%	38.0%	8.7%
	private	11,445 (1.00)	11,750 (1.00)	13,394 (1.00)	2.7%	7.7%	12.0%

(Note):
1) The number in parentheses is the ratio to the number for JRs.
2) The number in proportion of employees and labor productivity is only passenger JRs.
3) The unit for productivity is thousand passenger-km per each activity's employee.

ence. The main questions are as follows. First, in what kind of activity does productivity increase? In other words, did privatization improve each activity's productivity equally? Second, if it did not increase productivity equally by activity, then what kind of activity increased the most and what did the least? Last, have JRs caught up with large private railways in some kinds of activities? And we define productivity by activity difference as service output per employee in each activity. Here, we divided activity of rail service into five: 1) rail operation, 2) station, 3) track maintenance, 4) car maintenance, and 5) administration and engineering at headquarter. Table 3 shows each activity's proportion in employees and labor productivity. The labor productivity by activity difference is defined as output measure (i.e. passenger−km) per each activity's employee.

First of all, as for each activity's proportion in employees, the structure has changed very much since 1981. In 1981, station employees accounted for about 42% but in 1991 became 33%. Car maintenance employees accounted for 18% in 1981 but shrank to about 9%. Thus, in terms of proportion these two activities decreased between the period before and after privatization. On the other hand, other activities increased in proportion during these eleven years. Among these, the proportion of operators and conductors increased to 80% of the level of large private railways in 1991 but administration and engineering had already passed the level of large private railways by 27%.

These results show that probably before privatization, station and car maintenance activities might have used many more employees than larger private railways. After privatization, JRs might have more employees in track maintenance and administration activities than large private railways. In other words, in track maintenance and administration, JRs might not be able to attain employment reduction by privatization as in other activities.

As for productivity, JRs improved in station and car maintenance activities but could not do so in track maintenance and administration activities. The first interesting point is that there was not much difference in pro-

ductivity per operator and conductor between JRs and large private railways in 1991. Even before privatization, for example in 1981, the productivity difference between JRs and large private railways was smaller than in other activities. This result is very similar to the previous study. In the comparison of urban private and public railways in Japan by Mizutani (1993b), the productivity difference in operators and conductors was smaller than in other activities.

Second, the productivity difference in maintenance activities, especially track maintenance is still large. For example, productivity per track maintenance employee of JRs was still only 55% that of large private railways. Compared with the level in 1981 (before privatization), this productivity increased by only 134%. The possible reason why JRs' productivity in track maintenance remained lower than for large private railways might be that JRs have a much bigger network (e.g. longer linehaul and more lines) than large private railways. Furthermore, the contracting−out scheme in maintenance activities, which large private railways often take, might be another reason for private railways' higher productivity figures.

Last, clearly JRs' productivity per administrative and engineering employee at headquarters was significantly below the level of large private railways. In the previous study by Mizutani, there was not a big difference between private and public railways. JRs' bigger network might require more administrative employees, and the operation of the Shinkansen (bullet trains) might require more engineers at headquarters. However, a 43% difference in productivity is still large enough to justify looking for other reasons.

2.4. Productivity Difference Among JRs

In the previous two sections, we compared JRs as one sector with large private railways. However, strictly speaking, after privatization JRs are no longer one company but have become separate independent rail companies. Here we will analyze the productivity difference among individual JRs, especially the difference between the three largest JRs in Honsyu (henceforth

TABLE 4 Labor Productivity and Employees Comparison Among JRs

(A) labor productivity (thousand)									
	Honsyu 3 JRs				3−islands JRs				private railways
year	JR East	JR Central	JR West	average	JR Hokkaido	JR Shikoku	JR Kyushu	average	large private
1987	1293 (0.69)	2034 (1.09)	918 (0.49)	1268 (0.68)	324 (0.17)	444 (0.24)	562 (0.30)	449 (0.24)	1863 (1.00)
1988	1511 (0.79)	2245 (1.17)	1003 (0.52)	1442 (0.75)	375 (0.20)	595 (0.31)	584 (0.30)	499 (0.26)	1922 (1.00)
1989	1636 (0.84)	2329 (1.20)	1014 (0.52)	1518 (0.78)	377 (0.19)	600 (0.31)	683 (0.35)	539 (0.28)	1939 (1.00)
1990	1725 (0.87)	2608 (1.31)	1125 (0.57)	1647 (0.83)	428 (0.22)	653 (0.33)	740 (0.37)	592 (0.30)	1985 (1.00)
1991	1868 (0.93)	2545 (1.26)	1162 (0.58)	1728 (0.86)	442 (0.22)	679 (0.34)	796 (0.39)	624 (0.31)	2019 (1.00)
% change (87-91)	44.5%	25.1%	26.6%	36.3%	36.4%	52.9%	41.6%	39.0%	8.3%
(B) total employees (persons)									
	Honsyu 3 JRs				3−islands JRs				private railways
year	JR East	JR Central	JR West	average	JR Hokkaido	JR Shikoku	JR Kyushu	average	large private
1987	80,796 (20.68)	20,231 (5.18)	49,881 (12.77)	50,303 (12.88)	12,111 (3.10)	3,768 (0.96)	13,636 (3.49)	9,838 (2.52)	3,907 (1.00)
1988	72,682 (18.71)	20,090 (5.22)	48,098 (12.38)	46,957 (12.09)	11,896 (3.06)	3,559 (0.92)	13,542 (3.49)	9,666 (2.49)	3,884 (1.00)
1989	69,176 (17.83)	19,881 (5.13)	48,236 (12.44)	45,764 (11.80)	11,590 (2.99)	3,386 (0.87)	11,549 (2.97)	8,842 (2.28)	3,879 (1.00)
1990	68,189 (18.38)	19,577 (5.27)	46,338 (12.49)	44,701 (12.05)	10,820 (2.92)	3,174 (0.86)	10,807 (2.91)	8,267 (2.23)	3,710 (1.00)
1991	67,441 (18.09)	20,479 (5.49)	46,193 (12.39)	44,704 (11.99)	10,867 (2.91)	3,129 (0.84)	10,468 (2.81)	8,155 (2.19)	3,729 (1.00)
% change (87-91)	−16.5%	−1.2%	−7.4%	−11.1%	−10.3%	−17.0%	−23.2%	−17.1%	− 4.6%

(Note):
1) The number in parentheses is in the ratio to the number for private (large) railways.

referred to as "Honsyu JRs") and the three-islands JRs (henceforth referred to as "3-islands JRs"). As a measure of productivity, we use passenger-km per employee. And we use labor productivity of large private railways as a benchmark.

As Table 4 shows, there is a large difference in labor productivity between Honsyu JRs and 3-islands JRs. In 1991, labor productivity of Honsyu JRs was about 2.8 times higher than that of 3-islands JRs. Honsyu JRs' productivity is considered almost equivalent to large private railways. For example, in 1991 Honsyu JRs' productivity was about 86% of large private railways. On the other hand, 3-islands JRs' productivity is closer to small private railways than to large private railways. The smallest JR, JR Shikoku, however, had 46 thousand employees in 1991. Compared with the largest private railway, Kintetsu's employees (11 thousand), the size of this JR is still very large. Thus, 3-islands JRs employees might still be too numerous for their service output level.

However, privatization with regional division has affected the productivity of 3-islands JRs. In terms of productivity growth, the growth rate of 3-islands JRs is the highest. Compared with Honsyu JRs, 3-island JRs' productivity growth was on average 3% higher from 1987-91. Compared with small private railways which have very similar demand conditions, the growth rate and productivity level of 3-island JRs are superior.

Thus, among JRs there is a polarization in labor productivity, with 3-islands JRs remaining lower than Honsyu JRs in productivity. But privatization could enhance productivity growth even in 3-islands JRs.

3 Labor Productivity and Employees Comparison : JR vs Private

3.1. Labor Productivity Model

The main problem with previous analyses of labor productivity comparisons is that factors (e.g. output level and network conditions) which affect labor productivity level have not been controlled at all. The main purpose of this section is to examine how much difference exists in labor productivity between JRs and large private railways after controlling factors such as

output levels and network conditions. It is also important to examine how and what kinds of factors previously mentioned affect labor productivity. In this analysis, we will apply the method which Mizutani (1993b) used in a private−public urban railway comparison.[3] Mizutani uses regression analysis to formulate the relationship of productivity to other conditions such as service output level (Q) and network conditions (N).

The basic formula for the labor productivity comparison model in Mizutani's study is assumed to be the Cobb−Douglas form as follows:[4]

$$PRD = f(Q, Ni, O, D)$$
$$\ln(PRD) = \alpha 0 + \alpha 1 * \ln(Q) + \Sigma \beta i * \ln(Ni) + \gamma * \ln(O) + \delta * D \qquad (3)$$

where
PRD = productivity (= Q/R)
Q = service output (e.g. passenger−km)
R = input (e.g. employees)
Ni = network factors (e.g. route−km, station spacing, number of line)
O = other factors (e.g. contracting−out, etc.)
D = dummy variables (e.g. public ownership dummy)

In these labor productivity comparison models, five kinds of labor productivity by activity difference are directly estimated. As dependent variables, the following are chosen: productivity per operator and conductor (PRDo), per station employee (PRDs), per track maintenance employee (PRDt), per car maintenance employee (PRDc), and per engineering and administration (PRDh). As explanatory variables, passenger−km as service and network variables such as route−km, number of lines and number of stations, and contracting−out index are chosen with ownership dummy (PUB). Therefore, five kinds of labor productivity comparison models are estimated.

By modifying the basic method above mentioned, the labor productivity comparison model between JRs and private railways could be estimated using a JR dummy variable (JR) instead of a public dummy variable (PUB).

Table 5 Estimation Results of Labor Productivity: Coefficients and Standard Errors

model dependent variable study	ope−1 ln(Q/EMPo) Mizutani	ope−2 ln(Q/EMPo) this study	stat−1 ln(Q/EMPs) Mizutani	stat−2 ln(Q/EMPs) this study	track−1 ln(Q/EMPt) Mizutani	track−2 ln(Q/EMPt) this study	car−1 ln(Q/EMPr) Mizutani	car−2 ln(Q/EMPr) this study	admin−1 ln(Q/EMPh) Mizutani	admin−2 ln(Q/EMPh) this study
Qpkm (passenger−km)	0.478 [0.034]	0.512 [0.079]	0.576 [0.022]	0.443 [0.062]	0.433 [0.060]	0.436 [0.080]	0.423 [0.026]	0.418 [0.077]	0.502 [0.095]	0.555 [0.103]
Lr (route−km)					−0.364 [0.076]	−0.361 [0.106]				
Nl (number of line)	−0.378 [0.063]	−0.441 [0.091]					−0.558 [0.076]	−0.427 [0.142]	−0.028 [0.314]	−0.486 [0.504]
lr(route−km per line)	−0.284 [0.059]	−0.294 [0.103]							0.272 [0.258]	−0.496 [0.386]
Ns(number of station)			−0.658 [0.037]	−0.463 [0.096]					−0.307 [0.319]	0.162 [0.529]
Ru(underground %)					−0.088 [0.063]	0.004 [0.013]			−0.104 [0.122]	−0.034 [0.019]
Rus(% of under station)			−0.127 [0.029]	−0.017 [0.009]						
Sl (load factor)	0.196 [0.094]	0.205 [0.223]								
CNT1(contract out for track)					0.869 [0.112]	0.743 [0.319]				
CNT2(contract out for car)							0.636 [0.077]	0.745 [0.310]		
JR (JR dummy)		0.185 [0.173]		−0.231 [0.208]		−0.437 [0.306]		−0.368 [0.219]		−0.149 [0.490]
PUB(ownership dummy)	−0.164 [0.079]		−0.412 [0.087]		−0.160 [0.205]		−0.405 [0.083]		−0.118 [0.348]	
a1 (constant)	5.725 [0.405]	5.194 [0.926]	5.704 [0.380]	7.719 [1.163]	5.089 [1.141]	5.446 [1.609]	5.629 [0.492]	5.238 [1.818]	5.686 [1.895]	5.523 [2.034]
R**2	0.8747	0.9291	0.9482	0.7975	0.8251	0.8550	0.7888	0.7502	0.6509	0.7769
sample size	163	23	80	23	69	23	157	22	51	22

note:
Q=passenger−km EMPo=operator & conductor EMPs=station employee EMPt=track maintenance employee
EMPr=car maintenance employee EMPh=administration & engineer
The results of"Mizutani"is obtained from"A Private−Public Comparison of Labor Productivity and Utilization in Japanese Urban Railways" "The 3rd International Conference on Competition and Ownership in Surface Passenger Transport," Toronto, Canada, September 26−29, 1993"

TABLE 6 Estimated Result of Labor Productivity Using Existing Productivity Model

method	owner−ship	PRDo (operator & conductor)	PRDs (station)	PRDt (track mainte−nance)	PRDr (car mainte −nance)	PRDh (administ−ration & engineer−ing)	EMP (total em−ployees)
case−1: simple average	JR	6864 (0.91)	4465 (0.76)	8153 (0.55)	16644 (0.83)	7622 (0.57)	26430 (7.80)
	Private	7504 (1.00)	5899 (1.00)	14727 (1.00)	20044 (1.00)	13394 (1.00)	3390 (1.00)
case−2: Mizutani (1993)	JR	7434 (1.38)	4740 (0.78)	8380 (0.84)	19513 (1.21)	7944 (0.38)	26430 (1.15)
	Private	5393 (1.00)	6105 (1.00)	9985 (1.00)	16173 (1.00)	20877 (1.00)	23020 (1.00)
case−3: this study	JR	6970 (1.20)	4249 (0.79)	7615 (0.65)	16138 (0.69)	8411 (0.86)	28449 (1.17)
	Private	5793 (1.00)	5353 (1.00)	11788 (1.00)	23316 (1.00)	9762 (1.00)	24276 (1.00)

(Note):

(1) (A) Case−1 shows results without controlling network conditions: Results are average for JR (6 passenger JR railways) and for Private (15 large private railways) in 1991. These are the same shown in Table 4.

(B) Case−2 shows results with controlling network conditions but using a private−public productivity comparison model: Results for JR are sample average and results for private are obtained by substituting JR's network variables in Mizutani model.

(C) Case−3 shows results with controlling network conditions and using a private−JR productivity comparison model: Results of both JR and private are obtained by substituting JR's network variables but 1 of JR dummy for JR (JR dummy is zero for private).

(2) (A) Equations for productivity estimation in Case−2 are as follows:

Mizutani's study (1993) : Private−Public Comparison Model

(a) $\ln(PRDo) = 5.725 + 0.478*\ln(Qpkm) - 0.378*\ln(Nl) - 0.284*\ln(lr) + 0.196*\ln(Sl) - 0.164*PUB$

(b) $\ln(PRDs) = 5.704 + 0.576*\ln(Qpkm) - 0.658*\ln(Ns) - 0.127*\ln(Rus) - 0.412*PUB$

(c) $\ln(PRDt) = 5.089 + 0.433*\ln(Qpkm) - 0.364*\ln(Lr) - 0.088*\ln(Ru) + 0.864*\ln(CNT1) - 0.160*PUB$

(d) $\ln(PRDr) = 5.629 + 0.423*\ln(Qpkm) - 0.558*\ln(Nl) + 0.636*\ln(CNT2) - 0.405*PUB$

(e) $\ln(PRDh) = 5.686 + 0.502*\ln(Qpkm) - 0.028*\ln(Nl) + 0.272*\ln(lr) - 0.307*\ln*(Ns) - 0.104*\ln(Ru) - 0.118*PUB$

(B) Equations for productivity estimation in Case−3 are as follows:

This study : Private−JR Comparison Model

(a) $\ln(PRDo) = 5.194 + 0.512*\ln(Qpkm) - 0.441*\ln(Nl) - 0.294*\ln(lr) + 0.205*\ln(Sl) + 0.185*JR$

(b) $\ln(PRDs) = 7.719 + 0.443*\ln(Qpkm) - 0.463*\ln(Ns) - 0.017*\ln(Rus) - 0.231*JR$

(c) $\ln(PRDt) = 5.446 + 0.436*\ln(Qpkm) - 0.361*\ln(Lr) + 0.004*\ln(Ru) + 0.743*\ln(CNT1) - 0.437*JR$

(d) $\ln(PRDr) = 5.238 + 0.418*\ln(Qpkm) - 0.427*\ln(Nl) + 0.745*\ln(CNT2) - 0.368*JR$

(e) $\ln(PRDh) = 5.523 + 0.555*\ln(Qpkm) - 0.486*\ln(Nl) - 0.496*\ln(lr) + 0.162*\ln*(Ns) - 0.034*\ln(Ru) - 0.149*JR$

where Qpkm = passenger−km Nl = number of line lr = route−km per line Sl = load factor(%) Ns = number of station Rus = % of underground station Lr = route−km Ru = % of underground CNT1 = contracting−out for track maintenance CNT2 = contracting−out for car maintenance PUB = ownership dummy(public = 1) JR = JR dummy(JR = 1)

(3) Unit: thousand passenger−km per employee

(4) PRDi: labor productivity for activity i, EMP: total employees

(5) Calculation of EMP is (A) Case−1 is actual number in 1991, (B) Case−2 is sample average for JR and simulated by using private−public comparison models for private, and(C) Case−3 is simulated by using private−JR comparison models.

The dependent variables and the explanatory variables except the ownership dummy variable used here are the same as in Mizutani's study. The sample for the estimation of productivity model is obtained using 6 JRs and 15 large and 2 medium private railways in 1991.[5] The estimation results are shown in Table 5 and 6, comparing with the results in Mizutani's study.

3.2. Comparison Estimated Labor Productivity

Table 6 shows a comparison of results in labor productivity by three different methods. Case−1 is the result obtained by dividing total passenger −km by total employees for each group (JRs and large private railways). This case shows the same results as those shown in Table 4, which is considered a case without controlling output level and network conditions. Case −2 shows results obtained by using Mizutani's private−public productivity comparison model. The productivity of JR in case−2 is a sample average in labor productivity among six passenger JRs. On the other hand, the productivity of private (the second row in case−2) is obtained by substituting an average JR's values of explanatory variables into the private−public productivity comparison models. Therefore, the private's productivity numbers are obtained by substituting the explanatory variables of the hypothetical private railways, which have the same output level and network conditions as an average JR. Case−3 shows results obtained by using regression results obtained here. The JR's productivity in case−3 is obtained by taking a JR dummy of a unity (JR = 1) but private is taking zero in JR dummy.

From this table, first, most results suggest that JRs' labor productivity is still 20−30% less than that of large private railways. It is true that on average the labor productivity of JRs is still less than for private, while JRs' productivity has increased dramatically since the privatization scheme was initiated. Second, however, the productivity difference between JRs and large private railways is not simple: the degree of productivity difference varies by activity. In station and maintenance activity, the productivity difference is larger. But in operation (e.g. operator and conductor), JR's productivity becomes even bigger than for private railways. In contrast with

case−1 (simple average comparison), the productivity difference between JRs and private railways of case−2 or case−3 becomes smaller. This suggests that it is important to control the service output level and network conditions to evaluate the true productivity difference. Finally, JR still had 17 % more employees in 1991 than private railways under the same conditions. Therefore, it is still possible for JRs to increase labor productivity up to the level of private railways.

3.3. Several Policy Effects on Employment

As we saw in the previous analysis, JRs still have the potential to increase labor productivity, and they have made efforts to do so. It would be interesting to examine how JR could reduce its total number of employees using several policy options. We will take four possible options and simulate total employee reduction by using private−JR productivity comparison models:

1) case−1: perfect privatization (assuming that JRs are perfectly privatized and managed like large private railways)
2) case−2: 10% reduction in number of lines (assuming that unloaded lines are transfered to other transportation modes)
3) case−3 : 10% reduction in line haul length (reducing line length but not network)

TABLE 7 Policy Effects on Total Employees

case	policy option	average Honsyu JR		average 3−islands JR	
		employees	increase (% change)	employees	increase (% change)
case−0	base case (original)	45,188	−	7,784	−
case−1	perfect privatization	38,603	−6,585 (−14.6%)	6,738	1,046 (−13.4%)
case−2	decrease number of lines by 10%	44,566	−622 (−1.4%)	7,677	−107 (−1.4%)
case−3	decrease line haul by 10%	44,252	−936 (−2.1%)	7,599	−185 (−2.4%)
case−4	increase contract. out by 10%	44,755	−433 (−1.0%)	7,662	−122 (−1.6%)

4) case−4 : 10% increase in contracting out (increasing contracting−out index in maintenance activity by 10%)

Table 7 shows the simulation results of total employees for an average Honsyu JR and an average 3−islands JR. According to results in case−1 (perfect privatization), JR could reduce its total employees by about 15% from the present number of employees if JR behaves like a large private railway. This case is the biggest single indicator that labor productivity will be increased in the future. Compared with case−1, case−2 (10% reduction in number of lines) does not affect the reduction of total employees in terms of proportion. It brings about at most a 1.4% decrease. Even when JR decreases line haul length by 10% (case−3), it may have only a minor effect on the reduction of total employees. When JR increases contracting−out for maintenance activity, the overall effects are not large, but the effect is larger in 3−islands JR than in Honsyu JR. From these results, although it is difficult to evaluate precisely how the several policy options such as perfect privatization, abandonment of network, and increase in contracting−out increase productivity and reduce employees, simulation results may indicate that the effect of perfect privatization is large and that network reform could bring about only slight improvement.

5 Conclusion

Japan National Railways were privatized and divided into several regional railways in 1987. Through analysis, we obtained the following results:

(1) JR increased productivity dramatically and reduced employees but JR still had 17% more employees than large private railways in 1991, under the same output and network conditions.

(2) Activities with productivity differences between JR and private railways are station and maintenance activities. On the other hand, as for operators, there is not much difference in productivity.

(3) Productivity growth occurred during rather than after privatization. The productivity growth at pre−privatization period was low.

(4) Employment adjustment speed of JR is faster than that of private railways.

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Notes

1. See, for example, K. Muramatsu, *Analysis of Japanese Labor Market (Nihon no Roudou Shijo Bunseki)*, Hakutou Syobo, Tokyo, 1983, p.184.
2. From the results of the Private-JR productivity comparison model, total employees of private railways are about 85.33% of total employees of JR under the same network conditions. We assume that JR could reduce employees in the previous year by about 15%.
3. See, Mizutani, F., A Private-Public Comparison of Labor Productivity and Utilization in Japanese Urban Railways, *Proceedings of the Third International Conference on Competition and Ownership in Surface Passenger Transport*, Toronto, Canada , 1993 (forthcoming).
4. Alternative regression, which is taking input (R) as a dependent variable, might be more general because each railway would decide reasonable input level (R) to given service output level (Q), network condition (Ni) and so on. That is:

$$R = f(Q, Ni, O, PUB)$$

$$\ln(R) = \alpha 0 + \alpha 1^* \ln(Q) + \Sigma \beta i^* \ln(Ni) + \gamma^* \ln(O) + \delta^* D$$

The productivity obtained from this equation is the same as equation-(3) except for sign of coefficients and the coefficient of service output(Q).

$$\ln(PRD) = \ln(Q/R) = -\alpha 0 + (1-\alpha 1)^* \ln(Q) - \Sigma \beta i^* \ln(Ni) - \gamma^* \ln(O) - \delta^* D$$

5. In the regression analysis of labor productivity comparison, two medium private railways

(Kobe Dentetsu and Sanyo Dentetsu) are included because these two private railways are not very different from the large private railways and JR Shikoku (the smallest among JRs) in terms of service output levels and network.

References

Anderson, S. C. 1983 The effect of government ownership and subsidy on performance: evidence from the bus transit industry. *Transportation Research−A* 17A: 191−200.

Caves, D. W. and Christensen, L. R. 1980. The relative efficiency of public and private firms in a competitive environment: the case of Canadian railroads. *Journal of Political Economy* 88 : 958−976.

Eidan. 1990. *'90 Eidan Chikatetsu Handbook* December, Tokyo (Japanese)

Gomez−Ibanez, J. A. and Meyer, J. R. 1990. Privatizing and deregulating local public services: lessons from Britain's buses. *Journal of American Planning Association.* 56: 9−21.

Hankyu. 1991. *Handbook Hankyu '90.* July, Osaka (Japanese)

Hensher, D. A. 1987. Productive efficiency and ownership of urban bus services. *Transportation.* 14: 209−225.

Imashiro, M. 1992. Michikazu Miyata talks about rolling stock policy of Tokyo Kyuko Dentetsu (Tokyo Kyuko Dentetsu no syaryo seisaku wo kataru). *Transportation and Economy (Unyu to Keizai).* 52−3: 65−73 (Japanese).

Isoura, K, Sakamoto, S., Suda, Y. and Ito, T. 1992. Railway management and track maintenance (Tetsudo keiei to senro hosyu). *Transport and Economy (Unyu to Keizai).* 52−2 : 4−38 (Japanese).

Levinson, H. S. 1992. Urban mass transit systems. In *Transportation Planning Handbook,* ed. J. D. Edwards, Jr. pp.123−174. N.J: Prentice Hall.

Muramatsu, K. 1983. *Analysis of Japanese Labor Market (Nihhon no Roudou Shijo Bunseki)* Tokyo, Japan : Hakutou Syobo (Japanese).

Meyer, J. R. and Gomez−Ibanez, J. A. 1980. Measurement and analysis of productivity in transportation industries. In *New Development in Productivity Measurement and Analysis,* eds. J. W. Kendrick and B. N. Vaccara, pp.295−332. Chicago, IL: The University of Chicago Press.

Meyer, J. R., Kain, J. F. and Wohl, M. 1965. *The Urban Transportation Problem.* Cambridge, MA : Harvard Univ. Press.

Ministry of Transport. 1990. *Present Conditions of Private Railways (Minei Tetsudo no Genkyo).* Unpublished Report, December (Japanese).

Miyajima, M. and Lee, S. D. 1984. A study comparing the efficiency of local public enterprise and private enterprise: railway industry (Chiho koei kigyo to minkan kigyo no koritsusei no hikaku ni kansuru kenkyu: tetsudogyo wo reitoshite). *Journal of Public Utility Economics (Koeki Jigyo Kenkyu).* 36−1: 79−100 (Japanese).

Miyajima, M. and Lee, S. D. 1985. Management and efficiency in local public and private enterprises: a comparison in the case of railways (Chiho koei kigyo to minkan kigyo no koritsusei to kigyo kodo ni kansuru kenkyu: Tetsudogyo wo reitoshite). *Journal of Public Utility Economics (Koeki Jigyo Kenkyu).* 36−3: 69−103 (Japanese).

Mizutani, F. 1993a. *Japanese Urban Railways: A Private-Public Comparison.* Avebury, Aldershot, UK.

Mizutani, F. 1993b. A private-public comparison of labor productivity and utilization in Japanese urban railways. *Proceedings of the Third International Conference on Competition and Ownership in Surface Passenger Transport.* Toronto, Canada (forthcoming)

Mizutani, F. and Nakamura, K. 1994. Economic analysis of productivity of JR railways. *The 44th Annual Conference of Japanese Public Utility Economics.* June 3-4: 6-29

Nakamura, K. 1993. Options for privatizing railroads. J.F.Kennedy School of Government, Harvard University, mimeograph.

Nakamura, K. 1994. Privatization and deregulation of natural monopoly: the case study of Japanese National Railways. *Waseda Commercial Review.* 359: 1- 34 (Japanese).

Oka, K. 1989. Present conditions and future goals of Eidan subways (Eidan chikatetsu no genkyo to kongo no kadai). In *Urban Transportation (Toshi Kotsu)*, eds. H. Hirooka and Y. Watanabe. pp.119-136. Tokyo, Japan: Seizando (Japanese).

Pashigian, B. P. 1976. Consequences and causes of public ownership of urban transit facilities. *Journal of Political Economy.* 84: 1239-1259.

Perry, J., Babitsky, T. and Gregersen, H. 1988. Organizational form and performance in urban mass transit. *Transport Reviews.* 8: 125-143.

Pucher, J. and Markstedt, A. 1983. Consequences of public ownership and subsidies for mass transit: evidence from case studies and regression analysis. *Transportation.* 11: 323-345.

Sekiguchi, M. 1987. *Private Railways (Shitetsu).* Tokyo, Japan: Nihon Keizai Shinbuno. (Japanese).

Somu-cho. 1989. *Present Conditions and Problems of Rail Industry (Tetsudo Jigyo no Genjo to Mondaiten).* Tokyo, Japan: Ministry of Finance (Japanese).

Yamashita, T. 1992. Track maintenance at the Nagoya Railways (Nagoya Tetsudo no senro hosyu wo kataru). *Transportation and Economy (Unyu to Keizai).* 52-4: 58-63 (Japanese).

Yamauchi H. 1989. Management of private railways: rail sector (Shitetsu keiei: tetsukido bumon). In *Shitetsu Gyokai (Private Rail Industry)*, ed. Y. Fujii, pp.61-96. Tokyo, Japan: Kyoikusya (Japanese).