Review of Income and Wealth
Series 50, Number 3, September 2004

CPI QUALITY ADJUSTMENT AND PRODUCTIVITY GROWTH: RAILWAY SERVICES IN JAPAN

BY KIYOHITO UTSUNOMIYA*

Hitotsubashi University

In recent years quality adjustment of price indices has been vigorously explored and the hedonic regression method has become popular in official statistics. In service sectors, however, the current CPI seems not to have been successfully adjusted to accommodate quality changes. In this paper I focus on the railway industry in Japan, where quality change is a vital factor in the measurement of price indices and productivity. Using hedonic regressions to adjust CPI railway fares, the paper suggests that there may be a significant degree of upward bias in the current CPI railway fares. Also, this leads to the results that the total factor productivity (TFP) of the Japanese railway industry, which is calculated by using the newly adjusted CPI as a deflator, has been improved contrary to previous research on this issue.

1. INTRODUCTION

While price indices are designed to measure price changes that arise from causes other than improvements in quality, it is extremely difficult to measure objectively the quality differences that occur over time. The failure to account properly for quality improvements, by making sufficient deductions from the Consumer Price Index (CPI), is said to cause upward bias[1] of the CPI. Recently, goods such as personal computers have been subject to a quality adjustment method known as the hedonic regression. This method is not currently being applied to the prices of services. The upward bias problem causes the overestimation of deflators that make use of the CPI, and results in the underestimation of the real value produced by services. The often-quoted low productivity growth of service industries is partly affected by such measurement errors.

This paper deals with the railway industry, in which such problems may be considered particularly acute. Studies on measuring railway productivity have been motivated by the issue of decreasing productivity in a railway industry which was a typically regulated industry. Since the division and privatization of the Japanese National Railway (JNR) in 1987 was a leading reform, followed by the U.K. and Germany, the change in the productivity of Japanese railway industry has been attracting attention not only from academic researchers but from policy makers in the world. However, the existing studies are based on the conventional idea that the output of railway industry is calculated by transport volume. This ignores the

*Correspondence to: Kiyohito Utsunomiya, Research and Statistics Department, Bank of Japan, 2-1-1 Nihonbashi-hongoku-cho, Chuo-ku, Tokyo,103-8660, Japan (kiyohito.utsunomiya@boj.or.jp).

[1]With regards to the problem of CPI bias, the Boskin Report (Advisory Commission to Study the Consumer Price Index, "Toward a More Accurate Measure of the Cost of Living," released in the United States in 1996) received attention for its estimate that the U.S. CPI had an upward bias that averaged 1.1 percent. In Japan, a similar upward bias of 0.9 percent has been estimated (Shiratsuka, 1999).

fact that capital and labor inputs in railway companies in Japan have been geared not merely towards transporting more people or greater quantities of goods but towards another goal: the provision of high quality service. If railway industry productivity is measured simply as the transport volume, then the increase in capital input will not result in productivity improvement.

This paper estimates CPI railway fares, taking into account the improvement in the services provided by the railway industry; it also measures the real productivity growth of the railway industry in Japan. Section 2 provides an overview of the issues surrounding quality in railway services and the inclusion of railway fares in the CPI. Sections 3 and 4 estimate the CPI, making appropriate adjustments for the mitigation of congestion on urban rail routes and for improvements in journey time. In Section 5, using this quality adjusted CPI, I measure growth rates in the total factor productivity (TFP) of major Japanese railway companies.

2. Quality of Railway Services and CPI Railway Fares

The basic role of the transportation industry is to transport people and goods to their destinations. Fares are prices that are basically determined by such factors as transport distance. However, transportation services also provide us with choices concerning the journey time, the quality of the accommodation within which we travel, and other traveling conditions. Railway services are no exception. In recent years, in fact, railway policy in Japan has not simply placed importance on increasing the transport volume, but has focused on raising the quality of services offered by the railway industry. For example, the Council for Transport Policy Deliberation published Report No. 13[2] on railway planning in 1992, pointing out firstly that the main line railways do not make sufficient provision for journey time and comfort, and secondly specifying the standard of practical infrastructure that would be required in order to reduce average journey times significantly. For urban railways, the report also set a numerical target for mitigating congestion during commuter hours.

The current Japanese CPI actually defines fees for superior services including first class accommodation and express railway fares as separate items. In this sense the prices already to some extent distinguish between products of varying quality offered by different railway companies. It should be noted, however, that making adjustments for quality in the CPI is different from adopting various service fees as separate items included in the CPI. If the fees within each service category (first or standard class; express or regular etc.) always changed in response to greater speed, train accommodation improvements, and other characteristics, then quality changes would also be reflected in the CPI. This does not actually occur, and basically only the nominal price changes are reflected. Therefore, if the railway industry carries out quality improvements that are reflected in neither top-up service fees nor standard fares, this will cause an upward bias in the CPI.

In recent years there have been already several ongoing debates about optimal methods for addressing upwards bias in the CPI. Quality adjustment for items

[2]Council for Transport Policy Deliberation Report No. 13, “Basic thinking on mid to long-term railroad improvements for the 21st century.”

subject to rapid technological innovation such as computers, televisions, and video cameras is an area in which progress continues to be made. However, research on quality improvement in public transportation service, which has a certain amount of weight of the CPI, has barely been explored.[3]

In Japan the weight on total rail fares (JR and other companies) in the CPI, which is 1.54 percent on a national basis and 2.25 percent in the Tokyo area, greatly exceeds the total weight on laptop and desktop computers (0.54 percent nationally, 0.56 percent for the Tokyo areas), it also exceeds the weight used for recreational durables including televisions (1.17 percent nationally, 1.17 percent for the Tokyo area). In the Tokyo area it is almost equal to the total weight for all household durables (2.24 percent). Thus, if the quality of railway services really improves, making the appropriate adjustments when constructing the CPI is even more important for this service category than for individual durables.

In general, quality adjustment for service sectors is difficult for two reasons: the definition of quality in service sectors is vague, and even where we can establish a working concept of quality, it is not easily quantified. Fortunately, quality concepts in the railway services are comparatively clear. As the Transport Policy Council mentioned, the most important service quality problems facing the Japanese railways are mitigating congestion on urban lines, and reducing average journey time and improving accommodation on the main lines. Therefore, if we are able to measure the equivalent monetary value placed upon such quality improvements by applying the hedonic approach and other methods, we can estimate quality adjusted railway fares.

3. The Influence of Mitigating Congestion in Urban Railways

First, I focus on the effect of mitigating congestion on urban lines, making the requisite quality adjustments to CPI railway fares.

Congestion Rates in City Areas

Figure 1 shows the changes in the congestion rates during peak times in the three major Japanese urban areas, combining the transport capacity and the number of passengers.[4] Although there are some minor differences between the congestion rates observed in the Tokyo, Osaka, and Nagoya metropolitan areas, there is one notable overall trend common to all three: transport demand started to decrease after peaking in the early 1990s. Nevertheless, transport capacity has continued to increase, and thus progress has been made in mitigating congestion rates.

Estimating the Cost of Congestion

Attempts to estimate the equivalent monetary value placed upon congestion on urban railway lines in Japan have been actively conducted in the transport

[3]In the U.S. there are examples of attempts to quantify quality in relation to the measurement of air transport productivity (cf. Morrison and Winston, 1989; Gordon, 1992). Passenger transport, however, is not the main focus for railways.

[4]Transport capacity is a value derived from multiplying the number of trains by the number of carriages per train at a particular time, and the congestion rate is the actual number of passengers divided by the transport capacity.

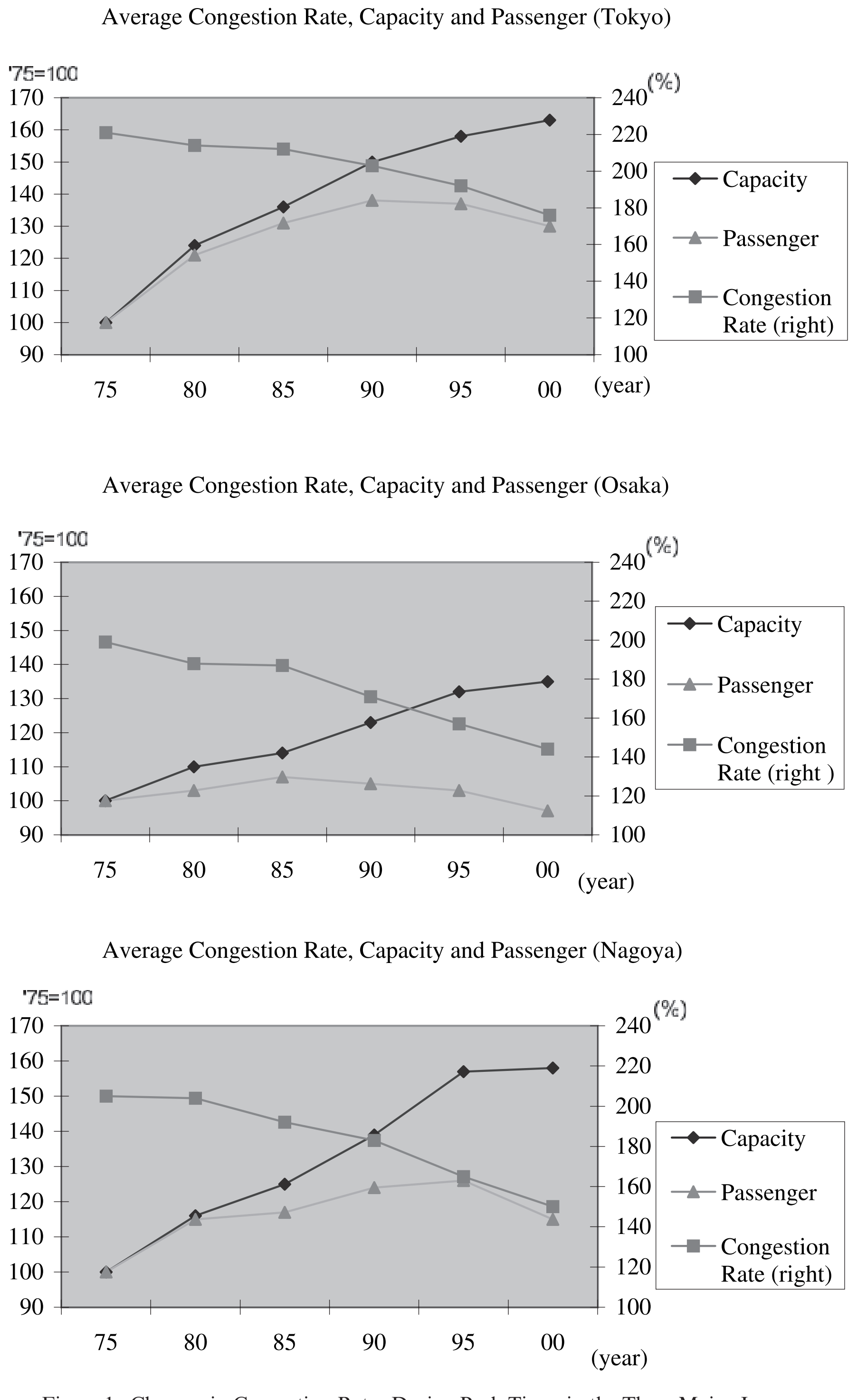

Figure 1. Changes in Congestion Rates During Peak Times in the Three Major Japanese Urban Areas

Source: Ministry of Land, Infrastructure, and Transport (2001).

engineering field. This is because evaluating the benefits is an essential part of the cost-benefit analysis that precedes the construction of new railway lines. The transport engineering methodology derives the relationship between the congestion rate and the congestion disutility from a model built from data such as passenger preferences, journey times, and congestion rates. Passenger preferences are usually estimated from survey research. On the other hand, economists' main concern has been estimating the "congestion fee," which is a measure (used widely in, for example, peak-road pricing studies) of the cost of the externality imposed upon transport-users (here rail-users) by congestion. Some economists in Japan have estimated these costs of congestion using housing rent data, based on the theory that differences in local transport system levels of capitalization are reflected in housing rent and land prices.[5]

However, it is not easy to apply these approaches to CPI adjustment. The transport engineering methods evolved in order to estimate the benefits accruing to individual construction projects in specific sections of given railway networks. This type of project-specific data cannot be easily adapted to macro statistics like the CPI. Moreover, even if the estimated value for a specific section of track is used as a macro proxy variable, data compilers at national statistical offices cannot ignore the costs incurred to collect the data needed to carry out these calculations. There is a similar data-collection problem with the economists' approach using rent and land price data.

Hedonic Approach Using the Seat Reservation Fees

This paper focuses attention on reserved seat trains, which have been increasingly introduced in recent years by the regional JR companies (hereafter the JRs) and other private railway companies, during commuter hours. These trains essentially make it possible to avoid commuter congestion by simply adding an extra reserved seat fee to the usual fare.

In spite of reforms, the railway fare in Japan is, as in other countries, to a certain extent still regulated, while fees such as limited express and seat reservation fees, a marginal portion charged separately from the fares, are comparatively flexible. Supply and demand seem to be reflected in the seat reservation fees because passengers can choose ordinary commuter trains as substitutes if they believe the fees are too expensive. Thus, if the seat reservation fees are significantly explained by congestion rates and other railway service characteristics, we will be able to write down a hedonic function for the shadow prices of these characteristics.[6]

The data used for estimation are the ratios of seat reservation fees to fares (the fees ratio) and the peak period congestion rates on 17 routes[7] of the major private railway companies(excluding the JRs),[8] where reserved seat trains travel

[5]See Yamazaki and Asada (1999) and Yamaga and Hatta (2000).

[6]In peak periods these seats are fully reserved well before their departure, so it is possible that the fees are set lower than the equilibrium price. This suggests that the calculation results below should be seen as conservative values.

[7]As it is necessary for reserved seat trains and ordinary commuter trains to be substitutable for the same route, the selection of routes is limited to the range in which the time required for the substituted commuter train is over 20 minutes but less than one hour.

[8]JR data was also viewed, but was not used here because the prices set uniformly across the lines appear to ignore supply and demand.

during commuter hours. One of the reasons for using the ratio of fees in the calculation instead of simply using the level of the seat reservation fee is to make it easier to adjust the CPI railway fares to account for quality changes. By finding the relationship between the ratio and the quality offered, we can directly estimate the CPI railway fares appropriate to given changes in quality. In addition, it is plausible that the consumers receiving the service often judge whether the seat reservation fee is reasonable compared to the fare.[9] Both the data for 1997, when the major private railway companies implemented price changes, and the data for 1996, before the changes, are used.

Estimation Results

Figure 2 simply plots the data for each route. This reveals a positive correlation between the congestion rate and the fees ratio. The route that diverges lower is the Keihin Express Railway, which has its network in the southern part of the Tokyo metropolitan area. The seat reservation fees for the Keihin Express Railway show a relatively inexpensive fee ratio considering the severe congestion rate. This could be because only this company uses the same carriages for their reserved seat trains and commuter trains. All the other companies use exclusive carriages, which are obviously of different quality from those of the Keihin Express Railway, and the difference in accommodation quality may influence this divergence. Therefore, the accommodation difference observed for this company is treated in the following analysis as a dummy variable.

As well as being free from congestion and enabling ticket-holders to comfortably secure seats, reserved seat trains usually have other characteristics such as their destination arrival times being faster than ordinary commuter trains. In addition, if commuter fatigue is considered, the longer the commuting time in a crowded train, then the higher the consumer's disutility becomes. Thus the length of the commuting time itself could also influence the relative prices of the seat reservation fees.

The hedonic function is given by

$$P_i = f(X_{1i}, X_{2i}, X_{3i}, D_{Ai}, D_{Yi}),$$

where P_i is the fees ratio, X_{1i} is the congestion rate at peak times, X_{2i} is the ratio of the commuting time by reserved seat trains compared to ordinary commuter trains,[10] X_{3i} is the commuting time including stopping times, D_{Ai} is the accommodation dummy variable that equals 1 for the Keihin Express Railway and 0 for other railways, and D_{Yi} is the year dummy variable that equals 1 in 1997 and 0 in 1996. Several functional forms are also tried.[11]

The results in Table 1 show that the fees ratio is significantly correlated with the congestion rate while there is no clear relationship found with the relative speed

[9]The relationship between the congestion rates and the level data of extra fees was also investigated, but it was not statistically significant.

[10]P_i, X_{1i}, and X_{2i} are all measured in percentage terms.

[11]The income level of residents along the railway routes could also influence the demand for reserved seat trains. Therefore, if there is any difference in income between the routes, this should be included with the explanatory variables. This was not considered here as there was not any suitable income data for the residents along the railway routes.

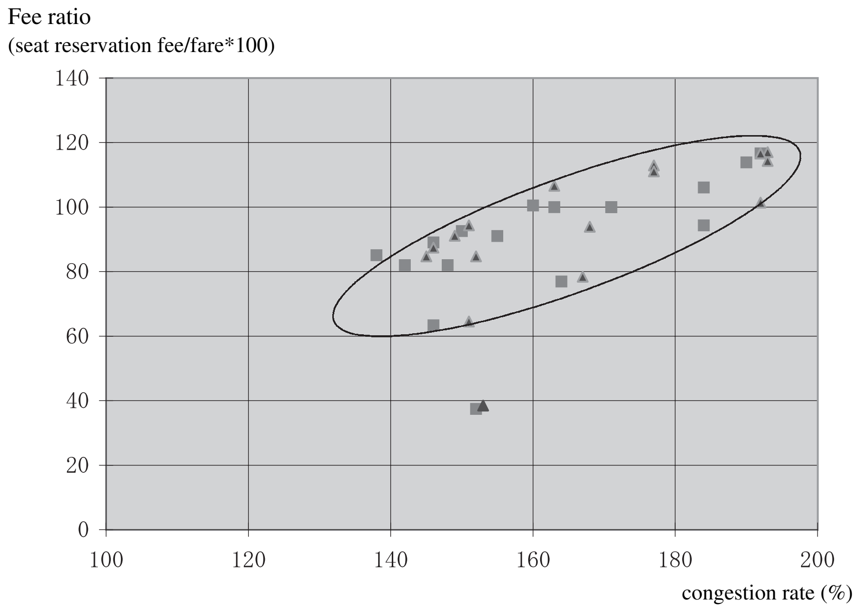

Figure 2. Fee Ratio and Congestion Rate

Note: The following 17 routes were selected on the condition that in either 1996 or 1997 travel time by alternative commuter train was from twenty minutes to one hour in rush hour. The Asakusa–Kasukabe route was excluded from the 1996 data because there was no reserved seat train for commuters in 1996.

Routes		Routes	
Asakusa	– Kasukabe	Shin-Nagoya	– Chiryu/Shinanjo/Higashi-Okazaki
Shinjuku	– Machida	Nanba	– Gakuenmae/Saidaiji/Kintetu-Nara
Shinjuku	– Hon-atsugi	Uehonmachi	– Yamatoyagi
Ueno	– Yashiyodai	Abeno	– Shakudo/Takada-shi/Kashiharajingu
Ikebukuro	– Tokorozawa	Kyoto	– Saidaiji
Ikebukuro	– Irumashi/Hanno	Nagoya	– Yokkaichi
Shinjuku	– Tokorozawa	Nanba	– Kongo/Kawachinagano/Rinkan-denentoshi/ Hashimoto
Shinjuku	– Sayama-shi		
Shinagawa	– Kamiooka/Kanazawabunko/ Yokosukachuo/Kurihama	Nanba	– Kishiwada/Izumisano/Misaki-Koen

of arrival at the destination or with the length of the commuting time. The result regarding the relative speed seems to reflect that there is little difference in arrival time between the reserved seat train and the substitute commuter express train for destinations located within one hour.[12]

The results from different sample periods are shown in Table 2. Linear regression is chosen for the functional form because it has the highest log likelihood. The estimated parameters are 0.600–0.656, which means that a 1 percent increase in the congestion rate matches around a 0.6 percent increase in the extra fees

[12]Reserved seat carriages with differing qualities of accommodation are attached to the same train for the Nagoya Railway. This means there is not any difference in arrival time.

TABLE 1

ESTIMATED RESULTS

	Linear	Semi-log(1)	Semi-log(2)	Double-log	Box-Cox
Intercept	–11.486	3.510	–440.020	–1.049	–102.680
	(29.983)	(0.317)**	(87.729)**	(0.928)	(227.730)
Congestion rate	0.641	0.007	105.640	1.094	0.437
	(0.120)**	(0.001)**	(19.587)**	(0.207)**	(0.070)**
Congestion speed	3.153	–0.058	6.694	–0.002	159.080
	(25.907)	(0.274)	(22.684)	(0.240)	(616.690)
Commute time	–0.048	0.000	–0.685	0.004	–0.120
	(0.294)	(0.003)	(9.950)	(0.105)	(0.508)
Dummy for accommodation	–49.452	–0.816	–50.270	–0.827	–944.350
	(8.012)**	(0.085)**	(8.038)**	(0.085)**	(173.800)**
Dummy for 1997	–0.690	–0.007	–0.708	–0.007	–20.033
	(3.458)	(0.037)	(3.472)	(0.037)	(75.086)
Box-Cox parameter	–	–	–	–	$\lambda = 1.71$
Adjusted R^2	0.759	0.821	0.756	0.820	0.730
Log likelihood	–118.677	–120.026	–118.832	–120.159	–118.360
Number of sample	33	33	33	33	33

Notes:
1. The sample consists of 16 routes in 1996 and 17 routes in 1997.
2. Semi-log(1) is the model where dependent variable is log-transformed.
3. Semi-log(2) is the model where explanatory variables are log-transformed.
4. Numbers in parenthesis are standard errors.
5. Double asterisks show statistically significant at the 1 percent level.

TABLE 2

ESTIMATED RESULTS

Sample	1996–97	1996	1997	1996–99
Intercept	–8.172	–12.820	–4.311	–4.289
	(16.380)	(25.478)	(21.594)	(11.356)
Congestion rate	0.629	0.656	0.600	0.606
	(0.097)**	(0.151)**	(0.132)**	(0.066)**
Dummy for accomodation	–49.334	–49.153	–49.415	–50.484
	(6.983)**	(11.031)**	(9.423)**	(4.750)**
Dummy for 1997	–0.781	–	–	–0.893
	(3.313)			(3.192)
Dummy for 1998	–	–	–	0.248
				(3.207)
Dummy for 1999	–	–	–	2.314
				(3.246)
Adjusted R^2	0.775	0.756	0.774	0.773
Log likelihood	–118.709	–58.604	–59.895	–240.025
Number of sample	33	16	17	67

Notes:
1. All regressions are linear.
2. From 1997 to 1999 each route has the same independent variable because its railway fare and fee are not changed in that period.
3. Numbers in parenthesis are standard errors.
4. Double asterisks show statistically significant at the 1 percent level.

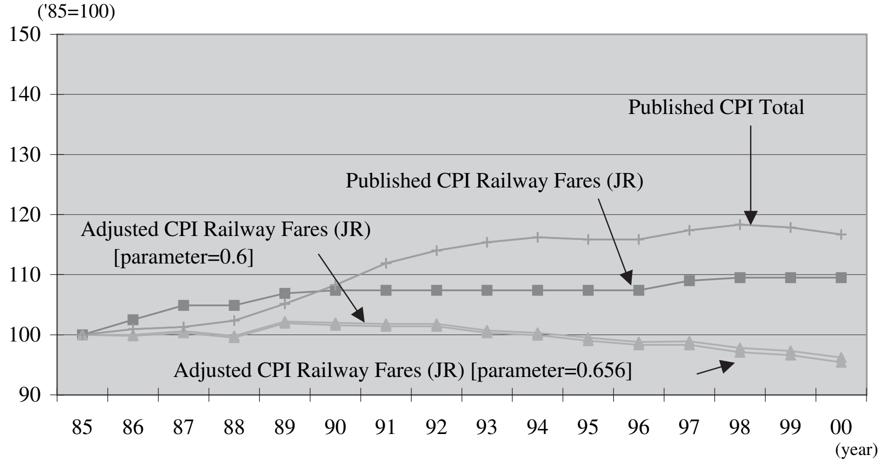

Figure 3. Railway Fares (JR) for Tokyo

ratio charges. The accommodation dummy is 49.1–50.5, suggesting that around half of the extra fees the consumers pay is for the difference in the quality of accommodation.

CPI Railway Fares After Congestion Rate Adjustment

Having obtained the percentage change in the fees ratio for each percentage point change in the congestion rate, the next step is to produce a quality-adjusted estimate for the Tokyo area CPI, where adjustments are calculated using changes in the average congestion rate for this area over time. This is shown in Figures 3 and 4. Although the adjusted CPI is plotted for two cases, both when the above parameter takes its lowest value, 0.6, and its highest value, 0.656, the difference observed between the two cases is extremely small.

The results for the JRs show that while there was little change in fares except for the introduction of the consumption tax, the 0.6 percent rise (converting the change for the period 1985–2000 into an annual rate) officially published in the CPI fell to 0.3 percent after adjustment because of the steady decline in congestion. The annual rate is 2.1 percent due to repeated price rises for the other railways in the 15 year period starting in 1985. Congestion rates eased noticeably in the latter half of the 1990s, reflecting the progress of infrastructure projects such as quadruple track lines and a slight reduction in passenger numbers. Therefore the CPI for the other railways after adjustment has decreased sharply in recent years.[13] There has been a 1.0 percent rise on an annual rate basis over 15 years.[14]

[13]While, for JR railway fares, the weight of factors that are unrelated to commute congestion (i.e. bullet train fares and limited express fares) is more than half the total, the influence of mitigating congestion appears larger for non-JR railway fares because there are only ordinary fares and commuter and student season tickets.

[14]This value is for the parameter of 0.6. It is 0.9 percent for 0.656. In the JR estimation both are the same. Hereafter, unless otherwise stated, the results of estimation use 0.6.

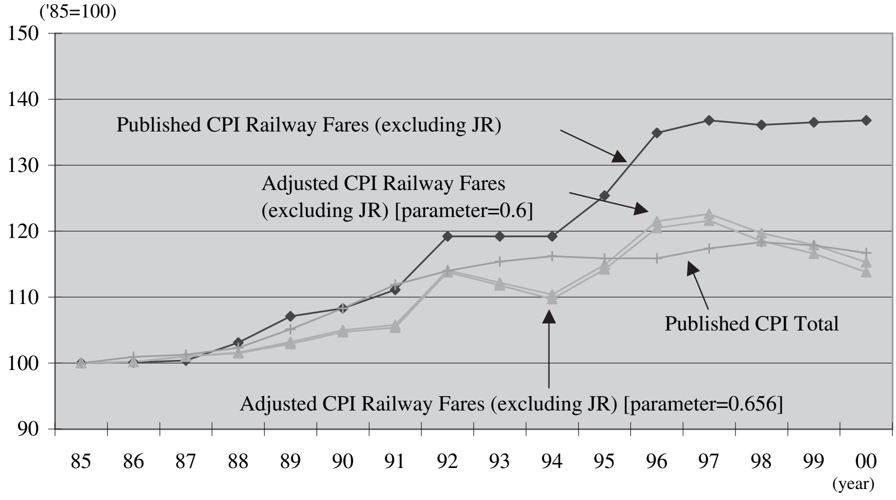

Figure 4. Railway Fares (excluding JR) for Tokyo

As noted before, considering the possibility that the prices for real seat reservation fees are low enough to cause excess demand, the results of the quality adjustment above are probably underestimated. Incidentally, the marginal fatigue cost per 1 percent rise in the congestion rate estimated by Yamaga and Hatta (2000) using housing rent data along the Chuo Line, one of the busiest lines in Tokyo, equals 0.726–1.369[15] on the fee ratio basis, which is considerably larger than the estimation results in this paper. This indicates that the CPI adjustments in this paper are fairly modest.

The estimation results for railway fares in the national CPI are shown in Figures 5 and 6. We run into a problem here because, although we would like to carry out similar CPI adjustments for the other major urban areas, it is only within the Tokyo ward that railway fares are published as an individual item in the CPI. To deal with this, we make use of the CPI for public transportation in the three main urban areas, Keihin (Tokyo-Yokohama metropolitan area), Chukyo (Nagoya metropolitan area), and Keihanshin (Osaka-Kyoto-Kobe metropolitan area); we then adjust the CPI for railway fares at the National level, by applying the adjustment values for the Tokyo CPI railway fares to that part of the index that represents urban rail transport—using the respective shares of each major urban area's expenditure on public transportation in the national total as the appropriate weights. Reflecting that the share of spending on public transport in these areas is higher than the national average, it is worth noting that the sum of these three areas respective shares of expenditure on public transportation makes up 52 percent of the national total. The result of this is that quality adjustment for

[15]The reason for the spread of the parameters is that, in Yamaga and Hatta (2000), the marginal fatigue cost is a function of commuting time and the congestion rate and that the value changes for each station. It is necessary to remember also that the congestion rate is a mean value and differs with train type. This paper chooses the value for the section with the highest congestion rate for each route, and takes into consideration the fact that the superior trains substituted for reserved seat trains generally suffer more from severe congestion than local trains.

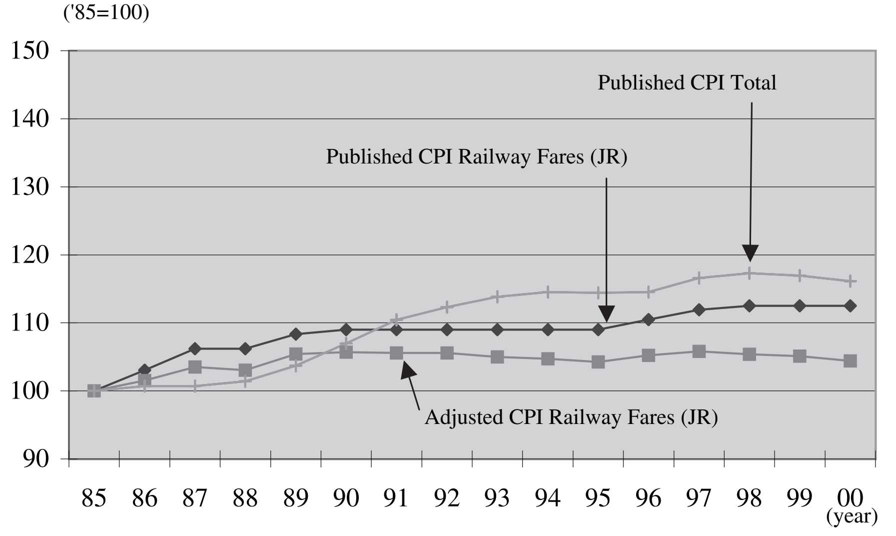

Figure 5. Railway Fares (JR) for Japan

Note: Adjusted CPI railway fares are calculated using the parameter of 0.6.

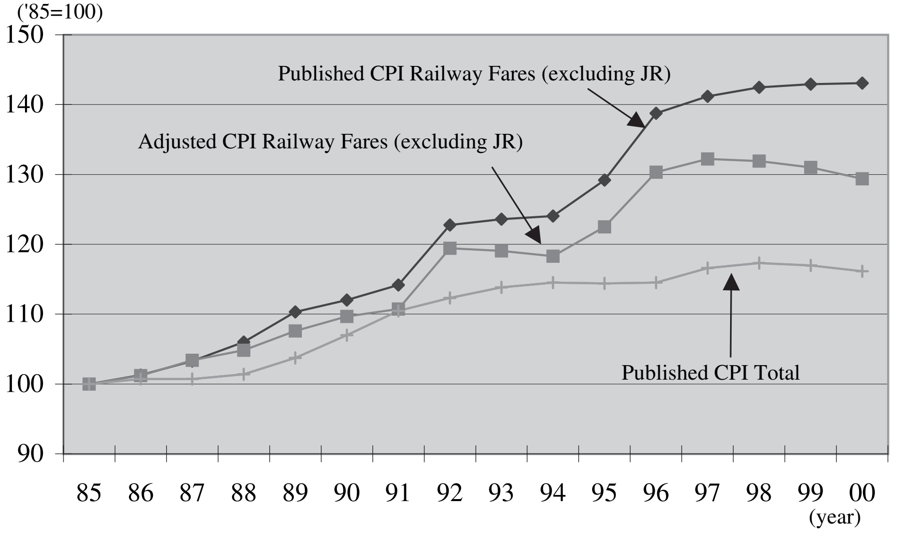

Figure 6. Railway Fares (excluding JR) for Japan

Note: Adjusted CPI railway fares are calculated using the parameter of 0.6.

congestion in the major urban areas also appears to have an influence on the national base values.[16]

[16]The average annual rates from 1985 to 2000 for JR are 0.8 percent in the officially published CPI and 0.3 percent after adjustment. For the other railways, they are 2.4 percent in the officially published CPI and 1.7 percent after adjustment.

4. The Influence of Improvements in Journey Time on Main Lines

Improving destination arrival time and accommodation on main lines has also been a policy aim. The effects of improvements in journey time on intercity routes are investigated using data from JR main lines.

Estimation Method

There has been a great deal of research into ways of establishing acceptable monetary equivalents to the value of time saved. In Japan the Ministry of Transport (1999) (hereafter, the MOT Manual) adopts two official approaches, the willingness-to-pay (WTP) method and the income method, and offers a standard equation for project evaluation. The first method investigates data on the prices people actually pay to save journey time, and the second makes direct use of macro statistics published on opportunity costs per hour.

The income method seems at first blush the more directly applicable to the CPI quality adjustment. The problem is that it uses macro data on wage income for calculating opportunity costs, and does not necessarily provide an accurate estimate of the value of non-labor hours.[17] This limitation of the approach must be considered when using the values in the MOT Manual.

Thus, in this paper I estimate the value of time saved by using a macro-based WTP method. My idea is to treat the difference in fees for a faster bullet train, the "Nozomi," and a normal bullet train, the "Hikari," as a WTP proxy for the value of time saved. The fact that the set price may be monopolistically determined could be problematic. However, since both bullet trains run frequently, the consumer can choose either one with a fair degree of freedom, and considering there is not a large difference between the two in terms of their respective congestion rates, the set price may be deemed a good reflection of actual supply and demand conditions.

Average Journey Time and the Value of Time Saved

The relative price ratios and time required for faster and normal trains are shown in Table 3. The mean value is used hereafter because the unit prices change subtly according to the section. As a reference I also adjust the CPI using the income method, where the mean time-value is 39.3/minute according to the MOT Manual.[18] The following calculation is based on the average time-saving over distances of 300 km for bullet trains and 150 km for conventional trains.

CPI Railway Fares After Adjustments for Reductions in Journey Time

First, looking at the changes in average speed (including time spent standing still) for bullet trains and conventional trains since 1985, we observe that all have

[17]The MOT Manual does not specifically determine the time value of non-wage hours, but it is generally supposed that the time value of non-wage hours is lower than the wage rate. The manual for road construction evaluation in the U.K., for example, sets a standard for the time value of non-labor hours at 25 percent of the wage rate (Department of Transport, 1994). Therefore, use of the income method in adjusting speed improvement may possibly result in over-adjustment.

[18]The MOT Manual calculates using the total average monthly cash wage of one ordinary worker from the annual report of monthly labor statistics in workplaces with more than five employees, and the total work hours for the same ordinary worker.

TABLE 3

PRICE AND JOURNEY TIME OF BULLET TRAIN

	Price (yen)			Journey Time (minute)			
	Faster Train (A)	Normal Train (B)	A/B (= E)	Faster Train (C)	Normal Train (D)	C/D(=F)	Price/Time (E – 1)/(1 – F)
Tokyo–Nagoya	11,340	10,580	1.072	96	110	0.873	0.564
Tokyo–Shin Osaka	14,720	13,750	1.071	150	170	0.882	0.600
Tokyo–Okayama	17,690	16,360	1.081	199	234	0.850	0.544
Tokyo–Hiroshima	19,680	18,050	1.090	231	275	0.840	0.564
Tokyo–Hakata	23,560	21,720	1.085	296	354	0.836	0.517
Average	–	–	1.080	–	–	0.856	0.555

Notes: Each price includes fare and extra fee for normal season. Each journey time is calculated based on the fastest train of its section.

Source: JTB Corp., "Timetable."

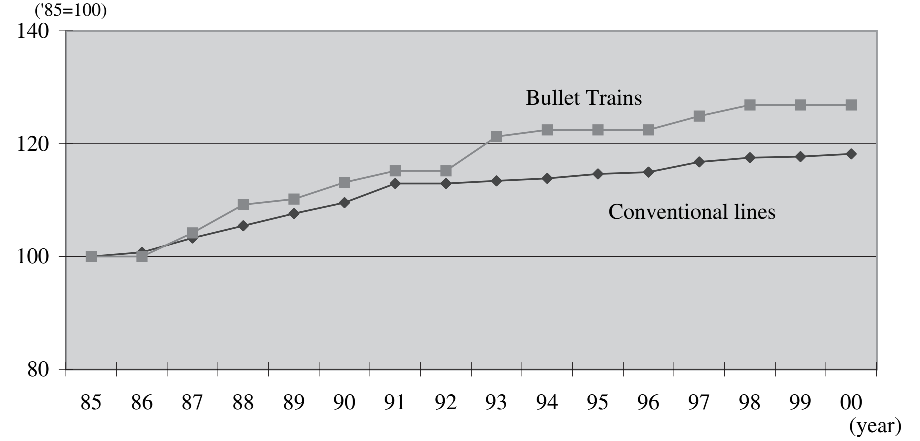

Figure 7. Average Speed (including time spent standing still) of Main JR Lines

Note: The indices above are average speeds (including time spent standing still) of 36 representative routes for conventional lines and seven representative routes for bullet trains respectively.

Source: Railway Bureau (1990–2001); JTB Corp., "Timetable."

steadily been increasing speed, as seen in Figure 7. This reconfirms that service quality in terms of journey time has been improving.

In order that the index may reflect these improvements, I estimate a quality-adjusted CPI, shown in Figure 8. In carrying out quality adjustment for journey time reduction, since the focus is on the high-speed intercity service, JR transport passengers within the three major metropolitan areas are excluded. Consequently, the consumer group consists of the remaining JR passengers (approximately 20 percent of total passenger numbers), and we take account of this when calculating the appropriate quality adjustment value.

The results show that, while the JR fees have been comparatively stable since the division and privatization of JNR, when we adjust the CPI for 2000 to account fully for the beneficial effects of journey time improvements and mitigated con-

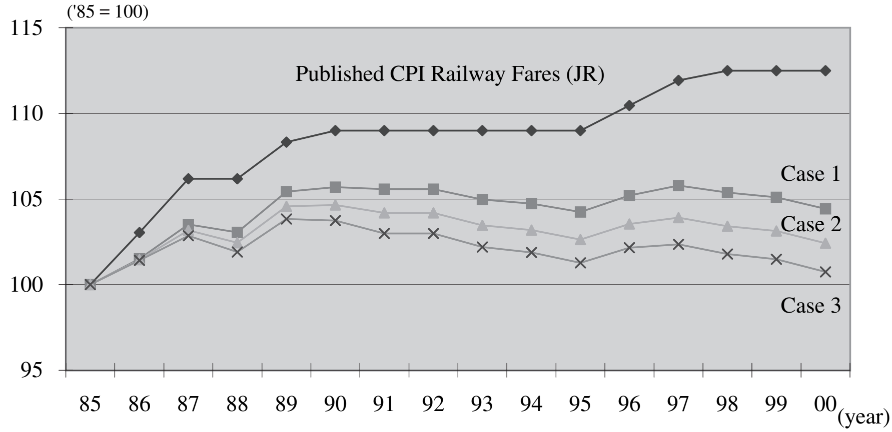

Figure 8. CPI Railway Fares after Adjustment (JR)

Notes:
Case 1: Compensates for the change in congestion rate.
Case 2: Compensates for the change in congestion rate and journey time using the WTP method.
Case 3: Compensates for the change in congestion rate and journey time using the income method.

gestion, it returns to its 1988 level (prior to the introduction of the consumption tax). This trend is even more obvious in the set of estimation results which make use of the income method to determine unit prices. Such strongly corroborative evidence suggests that our adopted WTP adjustment process, using the price difference between the fees for faster and normal bullet trains as a proxy for the value of time saved, cannot be considered an over-adjustment. Rather, considering that improvements have also been made in destination arrival times on commuter routes in major city areas, a factor not included in our results, it seems reasonable to suggest that these results are, if anything, on the conservative side.

5. Productivity Growth Reflecting Quality Improvement

Existing Research on Railway Productivity

There are a variety of studies on measuring railway productivity.[19] Studies in the U.S. and Europe have been carried out against the background of the serious decline in their railway industries under regulation, with the aim of uncovering a policy response capable of redressing this problem. Indeed the research results showed that the deregulation policy actually contributed to improving productivity.

In Japan there has also been some previous research in this area. Looking at railway industry productivity growth, Nakajima and Fukui (1996) carried out measurements of TFP growth prior to the division and privatization of the Japanese National Railway (JNR) in 1987. Oda and Otsubo (2000) measured the TFP growth of the JRs (Japan Railways) after the division and privatization of JNR, and compared their results with those of Nakajima and Fukui (1996).

[19]For debate on railway productivity, Oum *et al.* (1999) have carried out a comprehensive survey.

TABLE 4

RESULTS OF PRECEDING RESEARCH ON JAPANESE RAILWAY PRODUCTIVITY

Average Annual Percentage Rate of Change

	JNR/JRs		Major Private Railway Companies	
	1963–85	1988–97	1963–85	1988–97
Input	2.04	1.99	3.48	3.07
Labor	–0.74	–0.21	–0.47	–0.07
Capital	2.88	1.48	3.61	2.90
Land	0.05	0.64	0.17	0.14
Fuel	–0.13	0.07	0.18	0.10
Output	0.49	1.88	2.97	0.24
TFP	–1.52	–0.10	–0.49	–2.75

Note: Excludes Sagami Railway from major private railway companies in 1963–85.

Source: Nakajima and Fukui (1996); Oda and Otsubo (2000).

These results are briefly summarized as follows (see Table 4). First, with regard to the productivity growth of JNR, we note that its TFP decreased on average from 1963 to 1985 because outputs did not grow as much as inputs. After the division and privatization of JNR, growth in output was matched by growth in input, which meant that the TFP growth rate recovered to around zero percent. For major private railways excluding the JRs, the TFP growth rate from 1988 to 1997 was consistently high and negative, while the average TFP growth rate was approximately –0.5 percent from 1963 to 1985.

In addition to the above studies, Nakajima *et al*. (1996) separated the activities of the railway industry into three sectors, transport, train operations, and tracks, and measure TFP for each JNR activity. According to their results, while the TFP growth rate for the tracks and train operations sectors was negative, it was generally positive for the transport section, even under the nationalized organization.

Those prior studies are both informative and suggestive. However, their concept of railway industry output is still based on transportation volume. Decline in railway industry productivity is inevitable unless the aim of capital and labor investment is to increase transportation volume; in spite of the fact that capital and labor inputs in railway companies have been geared not merely towards transporting more people or greater quantities of goods but towards providing high quality service. Quality is an essential part of the output of the present-day railway industry.

In the next section, considering quality improvements, I estimate the productivity growth of the major private railway companies and the JRs.

Estimation Method

The analysis is based on the standard methodology for measuring TFP. The important point is that the quality-adjusted real transport index is regarded as the output, while the input is the well-known divisia index of capital, labor, and fuel. The quality-adjusted real transport index mentioned here is defined as:

$$Y_{t,t+1} = \frac{R_{t,t+1}}{P^*_{t,t+1}}$$

where $Y_{t,t+1}$ is the quality-adjusted real transport index in period $t + 1$ normalized by its value in the index reference period t, $R_{t,t+1}$ is the total transport revenue index in period $t + 1$ normalized by its value in the index reference period t, and $P^*_{t,t+1}$ is the quality-adjusted CPI in period $t + 1$ normalized by its value in the index reference period t.

That is, the quality-adjusted real transport index is the index of total transport revenue deflated by the quality-adjusted CPI calculated in the above section. The total transport revenue index is obtained by multiplying the unit price index by the transport volume index:

$$R_{t,t+1} = V_{t,t+1} \cdot P_{t,t+1},$$

where $V_{t,t+1}$ is the transport volume index in period $t + 1$ normalized by its value in the index reference period t, and $P_{t,t+1}$ is the unit price index in period $t + 1$ normalized by its value in the index reference period t.

The official CPI can be regarded as the actual unit price index. Consequently, the deviation between the official CPI and the quality-adjusted CPI is directly reflected in the index as the change of quality, as follows:

$$Y_{t,t+1} = V_{t,t+1} \cdot \frac{P_{t,t+1}}{P^*_{t,t+1}}$$

Estimation Results

The estimated results are shown in Tables 5 and 6. Data for the calculations are shown in Table 7.[20] Compared with the TFP estimates based on the transport volume, using the quality-adjusted real transport index causes the estimates of the TFP growth rate to change drastically. If transport volume is seen as the only output, TFP growth was negative throughout the 1990s for the major private railway companies. However, in the figures after adjustment, taking account of the congestion rate mitigation that occurred in the latter half of the 1990s as the result of previous investment and reductions in passenger numbers, we see how TFP growth is restored to positive territory. The JRs also show for the most part consistently high TFP growth since 1993.

Furthermore, these results reveal the effects of the recent drastic changes in the railway industry in Japan. As passenger volume for the major private railway companies has fallen further, infrastructure investment has been rapidly restrained and labor input has been reduced. Viewing the TFP growth rates both before and after adjustment indicates that productivity appears to be improving, and this suggests that Japanese railway companies have been making progress with restructuring. Particularly notable have been the cuts made in the labor force over the

[20]Conventionally, capital input has been often separated into capital equipment and land. As land values fluctuated significantly in Japan around the bubble period, it is difficult to get an accurate grasp of the real input value which it is appropriate to assign to land. Fixed assets related to railway transportation on the balance sheets of railway companies are collectively taken as a capital input.

TABLE 5

PRODUCTIVITY GROWTH RATES OF MAJOR PRIVATE RAILWAY COMPANIES

Annual Percentage Growth

	Output		Input				TFP	
		(Adjusted)		Capital	Labor	Fuel		(Adjusted)
1986	2.43	2.33	5.45	4.41	0.99	0.05	–3.03	–3.12
1987	2.02	1.48	3.86	2.80	0.96	0.10	–1.84	–2.38
1988	2.55	4.75	0.80	1.77	–1.30	0.34	1.75	3.94
1989	0.77	3.01	2.21	2.52	–0.43	0.12	–1.45	0.79
1990	4.90	4.36	5.60	4.35	0.80	0.46	–0.69	–1.24
1991	2.05	3.71	3.94	3.87	0.03	0.05	–1.90	–0.23
1992	–0.50	–1.04	4.96	3.64	1.26	0.06	–5.46	–6.00
1993	–0.37	1.27	2.74	2.03	0.61	0.10	–3.11	–1.47
1994	–0.65	1.12	2.37	1.71	0.49	0.17	–3.02	–1.26
1995	–1.00	0.04	1.54	2.05	–0.54	0.04	–2.55	–1.50
1996	–1.13	0.56	1.35	1.66	–0.27	–0.04	–2.49	–0.80
1997	–2.90	–2.45	–0.62	0.75	–1.40	0.03	–2.28	–1.83
1998	–1.65	0.31	–0.64	0.74	–1.41	0.04	–1.01	0.95
1999	–1.22	0.53	–0.70	0.44	–1.19	0.04	–0.52	1.24
Average 1986–90	2.53	3.19	3.59	3.17	0.20	0.21	–1.05	–0.40
Average 1991–95	–0.10	1.02	3.11	2.66	0.37	0.08	–3.21	–2.09
Average 1996–99	–1.73	–0.26	–0.15	0.90	–1.07	0.02	–1.57	–0.11

TABLE 6

PRODUCTIVITY GROWTH RATES OF JRS

Annual Percentage Growth

	Output		Input				TFP	
		(Adjusted)		Capital	Labor	Fuel		(Adjusted)
1993	0.16	1.81	–0.45	–0.39	–0.18	0.13	0.61	2.26
1994	–2.26	–0.52	–0.37	–0.29	–0.11	0.03	–1.88	–0.15
1995	1.89	2.97	–0.45	–0.33	–0.24	0.11	2.34	3.42
1996	1.10	2.82	–0.32	–0.31	0.02	–0.04	1.41	3.14
1997	–1.62	–1.16	–2.13	–0.49	–1.61	–0.02	0.51	0.97
1998	–1.96	0.00	–2.24	–0.53	–1.71	0.00	0.28	2.24
1999	–0.83	0.93	–2.30	–0.30	–2.01	0.01	1.47	3.23
Average 1992–95	–0.07	1.42	–0.42	–0.34	–0.18	0.09	0.36	1.84
Average 1996–99	–0.83	0.65	–1.75	–0.41	–1.33	–0.01	0.92	2.39

Notes:
1. "Adjusted" numbers are calculated using the newly adjusted CPI as a deflator.
2. Major private companies are the companies that compose "the big 15" excluding JR.

past few years by JR companies eager to reduce their input costs, while at the same time they have suffered smaller decreases in transport volume than the major private railway companies. Thus, the improvement in the JRs' productivity seems striking in comparison with other companies. Nobody would have predicted the current situation before the division and privatization of JNR.

TABLE 7
DATA

		Output/Input	Revenue/Cost
Output		Passenger transport	Passenger revenue
Input	Labor	Total workers	Labor cost
		Estimated labor input[1]	Other expense (part)[2]
	Capital	Fixed asset[3]	Interest payment[5] Amortization
		Estimated capital input[4]	Material expense (part)[6]
	Fuel	Electric power	Power cost
		Fuel oil	

Notes:
1. Estimated labor input
= Total workers × (Other expense for labor/Labor cost).
2. Other expense for labor
= (Other expenses − Power cost) × (Labor cost/(Labor cost + Interest payment + Amortization)).
3. Fixed asset includes construction in process.
4. Estimated capital input
= Material expense/Deflator for fixed capital formation (1985 = 1).
5. Interest payment
= (Corporate bond issued + Long term loan) × Average contracted interest rate for long term loans.
6. Material expense
= (Other expense − Power cost) × (Interest Payment + Amortization/(Labor cost + Interest payment + Amortization)).

Source: Ministry of Land, Infrastructure, and Transport, "Railway Statistics Annual"; Bank of Japan, "Financial and Economic Statistics Monthly."

6. Conclusion

Taking into account improvements in the quality of the product offered by railway service companies, this paper adjusts CPI railway fares in Japan, and suggests that there may be a significant degree of upward bias in the current CPI. This overestimation of the CPI may have distorted previous analyses of the productivity of Japanese railways.

The results of the calculations are based on a number of assumptions. However, the methods demonstrated here have the merit of being comparatively easy to apply from the existing data. This will lead to improve the measurement of price indices and productivity in service sectors. Although the analysis in this paper is limited to the railways, the approach shown in this paper could be applicable to other transportation services. For example, while airfares have decreased in many countries under recent deregulation, the quality of passenger airline services may have also declined due to higher congestion rates and decreased punctuality. Heightened security controls seem to have significantly increased overall travel times. Considering that the current CPI ignores these factors, it is probable that the CPI is downward-biased, and that the productivity of airline industries is overestimated. Improvements in deflators by quality adjustment of the price indices can provide a new outlook on the productivity growth of an industry.

References

Advisory Commission to Study the Consumer Price Index, *Toward a More Accurate Measure of the Cost of Living, Final Report to the Senate Finance Committee*, December 4, 1996.

Bureau of Transport Statistics, *National Transportation 2000*, http://199.79.179.77/btsprod/nts/, 2001.
Department of Transport, *Design Manual for Roads and Bridges*, Vol. 13, 1994.
Gordon, R. J., "Productivity in the Transportation Sector," in Griliches, Z. (ed.), *Output Measurement in the Service Sectors*, University of Chicago Press for National Bureau of Economic Research, 371–427, 1992.
———, "Problems in the Measurement and Performance of Service-sector Productivity in the United States," *NBER Working Paper No. 5519*, March 1996.
Griliches, Z., *Output Measurement in the Service Sectors*, University of Chicago Press for National Bureau of Economic Research, 1992.
Lancaster, K., *Modern Consumer Theory*, Edward Elgar, London, 1991.
Morrison, S. A. and C. Winston, "Enhancing the Performance of the Deregulated Air Transportation System," *Brookings Papers on Economic Activity: Microeconomics*, 61–112, 1989.
Nakajima, T. and Y. Fukui, "Nihon no Testudojigyou no Zenyousoseisansei (Total Factor Productivity of the Japanese Railway Business)," *Transportation and Economy*, 56(1), 32–40, 1996.
Nakajima, T., K. Oda, and T. Takahashi, "Total Factor Productivity of the Japanese National Railways based on the '3T' Activities," *Keo Discussion Paper*, Series 45, Keio Economic Observatory, 1996.
Nordhaus, W. D., "Quality Change in Price Indexes," *Journal of Economic Perspectives*, 12(1), 59–68, Winter 1998.
Oda, K. and Y. Otsubo, "Kokutestsu Mineika Ikou no Tetsudojigyou no Zenyousoseisansei (Total Factor Productivity after Privitization of the Japanese National Railway)," *Transportation and Economy*, 60(2), 52–60, 2000.
Oum, T. H., W. G. Waters II, and C. Yu, "A Survey of Productivity and Efficiency Measurement in Rail Transport," *Journal of Transport Economics and Policy*, 33, 9–42, 1999.
Price Statistics Division, "Quality Adjustment of Price Indexes, Wholesale Price Index and Corporate Service Price Index: The Current Situation and Future Implications," *Research and Statistics Department Working Paper 01-6*, Bank of Japan, 2001.
Railway Bureau, *Cost Benefit Analysis Manual for Railway Project 99*, Institute for Transport Policy Studies, 1999.
———, *Suji de miru Tetsudo (Railway Statistics Annual Handbook)*, Institute for Transport Policy Studies, 1990–2001.
Rosen, S., "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy*, 82, 35–55, 1974.
Shiratsuka, S., "Measurement Errors and Quality-Adjustment Methodology: Lessons from the Japanese CPI," *Economic Perspectives*, 23(2), 2–13, 1999.
Statistics Bureau and Statistics Center, *Consumer Price Index*, http://www.stat.go.jp, 2002.
Yamaga, H. and T. Hatta, "Tsuukin no Hirou Kosuto to Saitekiryoukin no Sokutei (Estimation of Fatigue Cost of Commuting and Optimal Congestion Fare)," *JCER Economic Journal*, No. 41, Japan Center for Economic Research, 110–31, 2000.
Yamazaki, F. and Y. Asada, "Testudou no Konzatsu kara Hsseisuru Shakaitekihiyou no Keisoku to Saitekiunchin (Estimation of Social Cost of Railway Congestion and Optimal Fare)," *The Quarterly Journal of Housing and Land Economics*, Vol. 34, Housing Research and Advancement Foundation of Japan, 4–11, 1999.