International Transport Forum

Valuation of Urban Rail Service

Experiences from Tokyo, Japan

01

Discussion Paper 2014 • 01

Hironori Kato
The University of Tokyo, Japan

OECD

Valuation of Urban Rail Service

Experiences from Tokyo, Japan

Discussion Paper No. 2014-1

Prepared after the Roundtable on
Valuing Convenience in Public Transport
(12-13 September 2013, Paris)

Hironori Kato
The University of Tokyo, Japan

January 2014

THE INTERNATIONAL TRANSPORT FORUM

The International Transport Forum at the OECD is an intergovernmental organisation with 54 member countries. It acts as a strategic think-tank, with the objective of helping shape the transport policy agenda on a global level and ensuring that it contributes to economic growth, environmental protection, social inclusion and the preservation of human life and well-being. The International Transport Forum organises an annual summit of Ministers along with leading representatives from industry, civil society and academia.

The International Transport Forum was created under a Declaration issued by the Council of Ministers of the ECMT (European Conference of Ministers of Transport) at its Ministerial Session in May 2006 under the legal authority of the Protocol of the ECMT, signed in Brussels on 17 October 1953, and legal instruments of the OECD.

The Members of the Forum are: Albania, Armenia, Australia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Chile, People's Republic of China, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Former Yugoslav Republic of Macedonia, Georgia, Germany, Greece, Hungary, Iceland, India, Ireland, Italy, Japan, Korea, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Mexico, Republic of Moldova, Montenegro, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and United States.

The International Transport Forum's Research Centre gathers statistics and conducts co-operative research programmes addressing all modes of transport. Its findings are widely disseminated and support policymaking in Member countries as well as contributing to the annual summit.

Discussion Papers

The International Transport Forum's Discussion Paper Series makes economic research, commissioned or carried out at its Research Centre, available to researchers and practitioners. The aim is to contribute to the understanding of the transport sector and to provide inputs to transport policy design.

ITF Discussion Papers should not be reported as representing the official views of the ITF or of its member countries. The opinions expressed and arguments employed are those of the authors.

Discussion Papers describe preliminary results or research in progress by the author(s) and are published to stimulate discussion on a broad range of issues on which the ITF works. Comments on Discussion Papers are welcomed, and may be sent to: International Transport Forum/OECD, 2 rue André-Pascal, 75775 Paris Cedex 16, France.

For further information on the Discussion Papers and other JTRC activities, please email: itf.contact@oecd.org

The Discussion Papers can be downloaded from: www.internationaltransportforum.org/jtrc/DiscussionPapers/jtrcpapers.html

The International Transport Forum's website is at: www.internationaltransportforum.org

TABLE OF CONTENTS

1. INTRODUCTION 5
2. THE GOVERNMENT'S COST-BENEFIT ANALYSIS MANUAL FOR RAIL PROJECTS IN JAPAN 6
  2.1. Cost-benefit Analysis Manuals in Japan 6
  2.2. CBA Manual for Rail Projects 7
  2.3. Estimation of User's Benefit in Rail Projects 7
  2.4. Definitions of Generalized Cost 8
  2.5. Methods of Valuing Rail Service Components 9
  2.6. Complementary Method of Valuing Transfer Improvement in Rail Stations 14
  2.7. Method of Valuing the Reliability of Rail Service 15
3. EXAMPLE OF VALUING URBAN RAIL SERVICE 2000 URBAN RAIL DEVELOPMENT MASTER PLAN IN TOKYO 16
  3.1. The Urban Rail Market in Japan: The Case of Tokyo 16
  3.2. 2000 Urban Rail Development Master Plan for Tokyo 17
  3.3. Rail Demand Analysis and Project Evaluation in the 2000 Urban Rail Development Master Plan for Tokyo 19
  3.4. Values of Rail Service Estimated in the 2000 Urban Rail Development Master Plan for Tokyo 20

CONCLUSIONS 24

ACKNOWLEDGMENTS 26

REFERENCES 27

1. INTRODUCTION

Promoting public transportation, which includes rail, metro, bus rapid transit, and bus services is one of the most popular urban transportation policies among transportation authorities in many countries. This popularity may reflect the social requirement to pursue a sustainable transportation system by motivating people to use an environmentally friendly transportation mode. In particular, the modal shift from the automobile to public transportation is highlighted in urban transportation planning because many cities have suffered from serious traffic congestion, which has caused economic losses as well as negative impacts on local, regional, and global environments. In order to attract individuals to use public transportation, the improvement of service is critical. This includes increasing service frequency, decreasing travel time, upgrading station facilities, and introducing higher-capacity vehicles. As most public transportation services are provided directly by public authorities or are financially supported by government/public-sector entities, an investment in public transportation is typically evaluated within a cost-benefit analysis framework. However, since public transportation service consists of many different components, including accessing public transit stops, waiting for the service, riding trains, transferring from one train to another, and exiting to a final destination, it is necessary to evaluate each component in detail. This has made it more difficult to analyze the benefit from public transportation projects than road projects. Thus, there is a strong need to develop a clear methodology by which to value the expected benefits stemming from a public transportation service change in monetary terms according to each service component.

This is also the case for Japan’s urban rail service. Japan’s Ministry of Land, Infrastructure, Transport and Tourism (MLIT) introduced the Cost-Benefit Analysis (CBA) Manual for rail projects in 1998 to provide a standard methodology for valuing rail service in Japan. This methodology has been applied to a number of rail projects in Japan that were subsidized by the central government. The Manual contains detailed methods for valuing the improvement of rail transportation services by the components of service as well as by their multipliers and parameters. Some parts of the CBA Manual may be highly dependent on the uniqueness of the Japanese urban rail market; however, it may be worthwhile for Japan to share its experiences with other OECD member countries. Additionally, although a number of studies have examined valuations of travel time for road traffic in Japan (for example, Kato et al., 2010b; 2011), valuations for public transit services have been rarely reported (an exception is Kato, 2007).

This paper aims to describe the government’s manual and report the recent practices of valuing urban rail transportation services in Japan. The remainder of this paper is organized as follows. First, the CBA Manual for rail projects in Japan will be introduced. The detailed methods for valuing rail transportation services are described. Next, the latest master plan for urban rail development in the Tokyo metropolitan area is presented, including the policy targets set in the plan. The characteristics of the urban rail market in Japan are also discussed. Then, the rail service values are computed with the travel demand model used in the master plan are presented. Finally, further issues are discussed with a summary of the paper.

2. THE GOVERNMENT'S COST-BENEFIT ANALYSIS MANUAL FOR RAIL PROJECTS IN JAPAN

2.1. Cost-benefit Analysis Manuals in Japan

The Government of Japan officially introduced the CBA to the evaluation of public-funded projects in 1998. The introduction of formal CBA Manuals reflected a political statement made by then-prime minister Ryuichiro Hashimoto, who requested the improvement of the effectiveness of public investment. (Note that various approaches, such as regional econometric models, hedonic models, and general equilibrium models, were informally used in an ad-hoc manner for project evaluation even before the official introduction of CBA in Japan.)

In Japan, various CBA Manuals have been made for different types of public infrastructure projects such as airports, railways, roads, seaports, agriculture, urban development, natural parks, rivers, and coastal projects. These CBA Manuals are developed independently by different bureaus under Japan's MLIT. Although the MLIT provides general guidelines (MLIT, 2009) that cover all transportation-related projects under them, the details of CBA Manuals vary among project types. Table 1 shows the latest CBA Manuals for transportation investment in Japan. The first CBA Manual for rail projects was published in 1998 (MLIT, 1998) by the Railway Bureau under the MLIT. It was established with support from advisory committees including experts in economics and transportation research. It has been revised three times: in 2000, 2005, and 2012 (MLIT, 2000; 2005; 2012). These revisions addressed additional policy requirements such as sophisticated methods of re-evaluation and post-evaluation, new evaluation methods for anti-disaster projects, the consideration of additional benefits from environmental impacts, and the introduction of updated techniques for benefit estimation. Although the CBA Manuals are available publicly online, they are exclusively in Japanese.

Table 1. **Latest CBA Manuals of Transportation Investment in Japan**

Type of project	Title	Latest updated
Airport	Cost-effectiveness Analysis Manual of Airport Development Projects Version 4	March 2008
Rail	Cost-effective Analysis Manual of Rail Projects 2012	July 2012
Road	Cost-benefit Analysis Manual	November 2010
Seaport	Cost-effectiveness Analysis Manual of Port Development Projects	June 2011

Source: Author

2.2. CBA Manual for Rail Projects

The CBA Manual for rail projects provides methods and examples of rail project evaluation. It covers not only urban rail service, but also inter-urban and rural rail services. The projects included in the Manual consist of new construction of rail lines, the improvement of existing rail lines, the improvement of rail stations, the installation of barrier-free rail service facilities, and anti-disaster rail investment, all of which are financed in full or in part by the national government. The Manual contains three types of project evaluations: pre-evaluation, re-evaluation, and post-evaluation. Pre-evaluation is implemented to analyze the feasibility of a new project; re-evaluation is implemented to examine the feasibility of the continuation of on-going projects of five years or more; post-evaluation is implemented to study the impacts of completed projects five years after project completion.

Conventional cost-benefit analysis theory (Small and Verhoef, 2007) is applied in the CBA Manual, where three indexes are produced from the economic analysis: the net present value, cost-benefit ratio, and economic internal rate of return. Periods of project evaluation are construction years plus 30 and 50 years. The social discount rate is four percent, which is assumed to be constant throughout the project period. Sensitivity analysis is required with respect to total travel demand, total project cost, and construction years. The benefit and cost stemming from a transportation project are computed assuming two scenarios: a without-project scenario and a with-project scenario. The benefit is classified into user’s benefit, supplier’s benefit, and other benefit. The user’s benefit is estimated with the consumer surplus approach based on travel demand analysis. The supplier’s benefit is computed with the net profit of rail operators. Other benefit includes environmental (dis)benefits such as the reduction of the emission of carbon dioxide from automobiles, changes in noise damage emitted from the rail service, and the existence benefit.

Although the CBA Manual does not explicitly provide a methodology for forecasting travel demand, it expects travel demand to be analyzed with a discrete-choice modeling approach (for example, Ben-Akiva and Lerman, 1985) for rail route choice analysis, particularly for urban rail projects. Note that for three major metropolitan areas in Japan, Tokyo, Osaka, and Nagoya, revealed preference (RP) about rail route choice data for rail users is available. The MLIT has implemented the Metropolitan Transport Census every five years since 1960, in which large-scale paper-based questionnaire surveys are administered with support from local public transportation operators, including rail companies and bus operators (ITPS, 2008). Respondents are requested to describe their daily travel using the public transportation service such as origin, destination, mode of travel to rail stations, chosen rail routes, departure time, and ticket type. Rail route demand analysis in the Tokyo metropolitan area typically uses multinomial logit or probit models with data from the Metropolitan Transport Census. The CBA Manual then uses the expected consumer surplus to estimate the user’s benefit when the discrete-choice approach is used for route demand modeling.

2.3. Estimation of User’s Benefit in Rail Projects

The CBA Manual shows the method for estimating the user’s benefit based on the concept of generalized cost. It assumes the origin-destination (OD)-based generalized cost. The benefit is computed using the “rule-of-half” formula, which is shown as

$$UB = \sum_{ij} \frac{1}{2}\left(GC_{ij}^{o} - GC_{ij}^{w}\right)\left(X_{ij}^{o} + X_{ij}^{w}\right) \tag{1}$$

where UB is the user's benefit, GC_{ij}^{o} is the generalized cost from zone i to zone j in the without-project scenario, GC_{ij}^{w} is the generalized cost from zone i to zone j in the with-project scenario, X_{ij}^{o} is the travel demand from zone i to zone j in the without-project scenario, and X_{ij}^{w} is the travel demand from zone i to zone j in the with-project scenario.

2.4. Definitions of Generalized Cost

The CBA Manual presents two approaches to define the generalized cost. The first approach uses a log-sum index, while the second approach does not. The log-sum index is the expected maximum utility or expected indirect utility computed from the multinomial logit (MNL) model (Williams, 1977).

Log-sum approach

This approach assumes that the MNL model is used for travel demand analysis in the context of travel modal choice or rail route choice. The generalized cost is computed with a utility function in the MNL as

$$GC_{ij} = \frac{1}{\partial V_{k,ij} / \partial F_{k,ij}} \ln \sum_{k} V_{k,ij} \tag{2}$$

where

$V_{k,ij}$ is the (indirect) utility function under the condition that an option (travel mode or rail route) k is chosen for travel from zone i to zone j and

$F_{k,ij}$ is the travel cost or fare in the utility function under the condition that an option (travel mode or rail route) k is chosen for travel from zone i to zone j.

As the utility function is typically assumed to be linear with a generic coefficient with respect to travel cost, the marginal utility with respect to income is constant. Thus, the following formula of the generalized cost is presented in the Manual:

$$GC_{ij} = \frac{1}{\hat{\theta}} \ln \sum_{k} V_{k,ij} \tag{3}$$

where $\hat{\theta}$ is the estimated coefficient with respect to travel cost in the utility function.

When the discrete-choice modeling approach is used, public transportation service values such as the value of travel time, value of service frequency, and value of crowding can be estimated with the empirical data in the travel demand analysis. However, they are not used to estimate the total user's benefit because they are implicitly incorporated into the utility function. Rather, they are often used to compute the shares of different benefit components of the total user's benefit.

Non-log-sum approach

This approach first assumes a route-based generalized cost. The Manual shows that the formula of the generalized cost of a rail route is as follows:

$$GC_{k,ij} = F_{k,ij} + \sum_{a} \left(\omega_a \cdot \sum_{pq} \delta_{k,ij,pq} \cdot T_{a,k,ij,pq} \right) + \sum_{b} \left(\omega_b \cdot \sum_{pq} \delta_{k,ij,pq} \cdot comf_{b,k,ij,pq} \right) \qquad (4)$$

where

$GC_{k,ij}$ is a generalized cost of rail route k from zone i to zone j;

$T_{a,k,ij,pq}$ is the travel time of link type a in a link from p to q of rail route k from zone i to zone j;

$comf_{a,k,ij,pq}$ is a comfort level of link type b in the link from p to q of rail route k from zone i to zone j;

$\delta_{k,ij,pq}$ is equal to 1 if the link from p to q is included in the rail route k from zone i to zone j and 0 otherwise;

ω_a is a value of travel time of link type a; and

ω_b is a value of comfort level of link type b.

The Manual cites in-vehicle travel, rail station access, rail station egress, and transfers at stations as examples of type-a links, whereas it cites in-vehicle comfort, convenience of transfer at stations, and service frequency as examples of type-b links.

Finally, the OD-based generalized cost is computed using the route-based generalized cost. The Manual proposes a weighted average method to estimate the OD-based generalized cost with the route shares of travel demand and the route-based generalized costs, although this method is not theoretically supported (Kidokoro, 2004; Kato et al., 2003a).

2.5. Methods of Valuing Rail Service Components

The Manual also presents methods for valuing each rail service component. These are primarily aimed at estimating the generalized cost in the non-log-sum approach, but are also used to compute the shares of different benefit components out of the total user's benefit even when the log-sum approach is applied.

In-vehicle travel time

User's welfare with respect to in-vehicle travel time is computed with a value of in-vehicle travel time as

$$\omega_{in-vehicle} \cdot \sum_{pq} \delta_{k,ij,pq} \cdot T_{in-vehicle,k,ij,pq} \tag{5}$$

where

$\omega_{in-vehicle}$ is the value of in-vehicle travel time;

$\delta_{k,ij,pq}$ is equal to 1 if a link from p to q is included in the rail route k from zone i to zone j and 0 otherwise; and

$T_{in-vehicle,k,ij,pq}$ is the in-vehicle travel time of the link from p to q in rail route k from zone i to zone j.

The Manual recommends that the value of travel time be estimated empirically with travel data because it may vary among regions and individuals' attributes. However, if the data is not available to estimate the value of travel time, the Manual requests that the analysts show the reason for it, and it allows them to use a standard value. The Manual presents the standard values in 2010, which are estimated with the government's statistics for the entire nation of Japan, Tokyo, and Osaka, as shown in Table 2.

Table 2. **Standard Values of Time in 2010 Estimated from Monthly Work Statistics Survey**

	Japan	Tokyo	Osaka
Value of time (JPY/min)	36.2	47.0	39.2

Source: 2010 Annual Report of Monthly Work Statistics Survey: Local Survey, Ministry of Health, Labour and Welfare, Japan.

Note 1: Values of time are computed by dividing the monthly average cash income of permanent workers working at workplaces with over four workers by the monthly average work hours of permanent workers.

Note 2: Table 2 shows the value of time in 2010. The latest statistics should be used when the data is available in the same manner as that shown in Note 1.

The Manual notes that the time values of children and elderly people who do not work should be equal to the standard value because another family member may have the willingness to pay to save travel time as an opportunity cost assuming the case where no rail service is available.

Rail station transfers

The Manual identifies two approaches to valuing the convenience of rail station transfers: a multiplier approach and a constant-parameter approach.

First, the multiplier approach assumes the following formula:

$$\alpha_{transfer} \cdot \omega_{in-vehicle} \cdot \sum_{pq} \delta_{k,ij,pq} \cdot T_{transfer,k,ij,pq} \quad (6)$$

where

$\alpha_{transfer}$ is a multiplier with respect to transfer time (= 2);

$\omega_{in-vehicle}$ is the value of in-vehicle travel time;

$\delta_{k,ij,pq}$ is equal to 1 if the link from p to q is included in the rail route k from zone i to zone j and 0 otherwise; and

$T_{transfer,k,ij,pq}$ is the transfer travel time of the link from p to q of rail route k from zone i to zone j.

This multiplier refers to past studies of rail route choice in Tokyo such as Yai et al. (1998). It should be noted that the above multiplier is higher with respect to transfer time (=2) than the multipliers with respect to transfer time by transfer type (= 0.89 to 1.65), which will be shown later in Table 4. This is probably because the above multiplier includes the psychological effect of transferring. It means that the above multiplier contains both the variable component that is in proportion to transfer minutes and the fixed component.

On the other hand, the constant-parameter approach assumes the following formula:

$$\omega_{in-vehicle}\left(10 \cdot \lambda_{transfer,k,ij}\right) \quad (7)$$

where

$\omega_{in-vehicle}$ is the value of in-vehicle travel time; and

$\lambda_{transfer,c,k,ij}$ is the number or frequency of transfers of rail route k from zone i to zone j.

This means that the constant-parameter approach assumes that the value of a unit transfer equals the value of 10-minute in-vehicle travel time.

In-vehicle crowding

The (dis)comfort of in-vehicle crowding is computed with the following formula:

$$\omega_{in-vehicle} \sum_{pq} \delta_{k,ij,pq} \cdot T_{in-vehicle,k,ij,pq} \cdot f\left(x_{pq}, cap_{pq}\right) \quad (8)$$

where

$\omega_{in-vehicle}$ is the value of in-vehicle travel time;

$\delta_{k,ij,pq}$ is equal to 1 if the link from p to q is included in the rail route k from zone i to zone j and 0 otherwise;

$T_{in-vehicle,k,ij,pq}$ is the in-vehicle travel time of the link from p to q in rail route k from zone i to zone j;

$f(\cdot)$ is an in-vehicle congestion function;

x_{pq} is the traffic flow in the link from p to q; and

cap_{pq} is the traffic capacity in the link from p to q.

The Manual shows the in-vehicle congestion function as presented in Table 3.

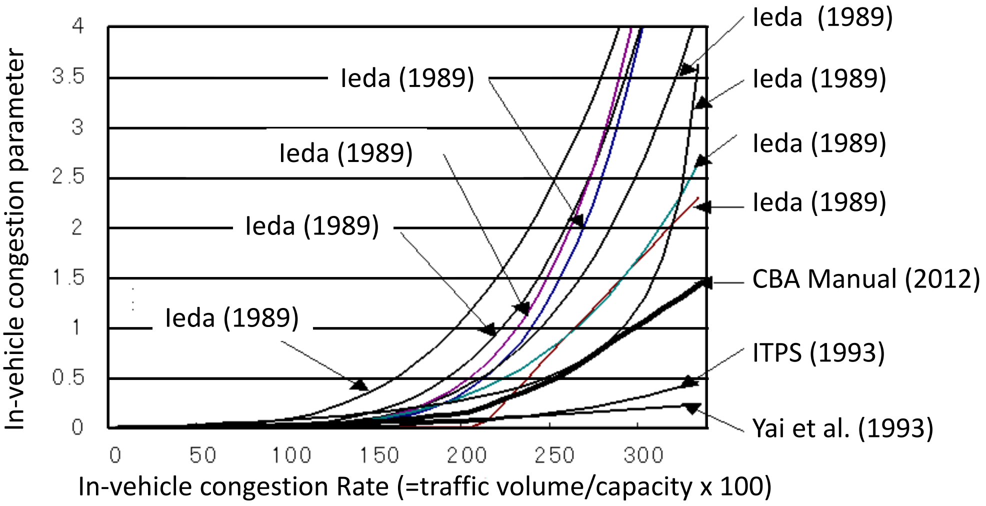
Table 3. **In-vehicle Congestion Functions Proposed by the CBA Manual**

In-vehicle congestion rate	In-vehicle congestion function
Less than 100 percent	$f = 0.0270R$
100 to 150 percent	$f = 0.0828R - 0.0558$
150 to 200 percent	$f = 0.179R - 0.200$
200 to 250 percent	$f = 0.690R - 1.22$
250 percent or more	$f = 1.15R - 2.37$

Note: R is the in-vehicle congestion rate, which is defined as the traffic flow over the traffic capacity, that is, $R_{pq} = x_{pq}/cap_{pq}$.

Figure 1 depicts the curves of the in-vehicle congestion functions, including the function shown in Table 3 and other estimates in Japan.

Figure 1. **In-vehicle Congestion Functions**



Source: Slightly changed from MLIT (2012)

It should be noted that the in-vehicle congestion function is not equal to the multiplier with respect to in-vehicle congestion and in-vehicle travel time. The multiplier with respect to in-vehicle congestion is given as

$$\alpha_{cong} = 1 + f\left(x_{pq}, cap_{pq}\right) \qquad (9).$$

The traffic capacity of rail service is typically defined in terms of hourly capacity. It is estimated using the passenger capacity of cars, the number of cars per rolling stock, and hourly service frequency. The passenger capacity of cars is defined by the Japanese Industrial Standards (JIS). Rolling Stock−General Requirements of Car Bodies for Passenger Cars (JIS E 7103, 2006) defines the passenger capacity as follows:

5.1 a) Passenger capacity: the passenger capacity is the sum total of seat capacity and standing capacity.

1) *Seat capacity: seat capacity is calculated by dividing the total width of all seats in a car body by the width of a seat occupied by a unit passenger, and it is rounded down to the nearest decimal. When there is no specific agreement about the seat capacity between the rolling-stock producer and the client, the width of the seat capacity occupied by a unit passenger is given to be 430 mm.*

2) *Standing capacity: standing capacity is calculated by dividing the available floor space by the space occupied by a unit passenger, and is rounded down to the nearest decimal. The available floor space is calculated by eliminating the seat area and the floor space within 250 mm of the front edge of seats from the total passenger space that has an effective width of 550 mm or more and an effective height of 1,900 mm or more. When there is no agreement about the standing capacity between the rolling-stock producer and the client, the space occupied by a unit passenger is given to be 0.3 m^2.*

2.6. Complementary Method of Valuing Transfer Improvement in Rail Stations

The Manual also presents complementary guidance for evaluating rail projects to improve transfers. This is because the government has recently called attention to rail station improvement projects in its goal of developing a seamless rail network. The Manual includes projects in rail stations for decreasing transfer time, lowering transfer barriers, reducing in-station congestion, and decreasing waiting time.

Multipliers of Transfer Time by Transfer Type

The Manual recommends that transportation planners primarily use travel demand models to value station transfers. The coefficients estimated in the travel demand model can be used to value transfers by transfer type when the travel demand model contains the variables with respect to the service level of going upstairs, going downstairs, using escalators, etc. The Manual presents a method to value transfers in stations by transfer type when such travel demand models are not available.

The following formula is presented for valuing transfers in stations:

$$\alpha_r \cdot \omega_{in-vehicle} \cdot T_{transfer,r} \tag{10}$$

where

α_r is a multiplier with respect to transfer type r;

$\omega_{in-vehicle}$ is the value of in-vehicle travel time; and

$T_{transfer,r}$ is the travel time of transfer type r.

The transfer types are walking upstairs, walking downstairs, walking on a flat floor, and using escalators. The Manual shows the multipliers as presented in Table 4.

Table 4. Multipliers with Respect to Transfer Time by Transfer Type

Transfer type	Walking upstairs	Walking downstairs	Walking on a flat floor	Using escalator
Multiplier	1.65	1.53	1.25	0.89

Source: Institution of Transport Policy Studies (2000)

Note that Kato et al. (2003b) also report the estimation processes and results of valuing transfer time by transfer type, which is the original source of Institution of Transport Policy Studies (2000).

Multiplier of Waiting Time in Stations

The Manual identifies two types of waiting times in stations: waiting time in front of stairs for passengers and waiting time at station gates for passengers who want to pass through the gates. It is assumed that benefits in this area stem from expanding the width of existing stairs in stations and installing new station gates.

The generalized cost of waiting time is formulated as follows:

$$\alpha_{wait} \cdot \omega_{in-vehicle} \cdot T_{wait} \tag{11}$$

where

α_{wait} is a multiplier with respect to waiting time (=1);

$\omega_{in-vehicle}$ is the value of in-vehicle travel time; and

T_{wait} is waiting time.

The Manual also suggests that the space occupied by a unit passenger is given to be 0.5 m^2; above this threshold, waiting queues occur.

2.7. Method of Valuing the Reliability of Rail Service

Although the Manual does not provide any official method of valuing the reliability of rail service, it includes an example of an estimation of the benefit stemming from the improvement of service reliability. According to this example, the multiplier with respect to delay is assumed to be 1. This means that the formula for valuing the reliability of rail service is

$$\alpha_{delay} \cdot \omega_{in-vehicle} \cdot T_{delay} \tag{12}$$

where

α_{delay} is a multiplier with respect to delay time (=1);

$\omega_{in-vehicle}$ is the value of in-vehicle travel time; and

T_{wait} is the time delayed from the given schedule.

3. EXAMPLE OF VALUING URBAN RAIL SERVICE: 2000 URBAN RAIL DEVELOPMENT MASTER PLAN IN TOKYO

3.1. The Urban Rail Market in Japan: The Case of Tokyo

Tokyo is one of the most populated cities in the world, with approximately 36 million people in its metropolitan area as of 2005. Tokyo is also well known to be a rail-oriented city: daily rail use demand was 26.22 million passengers in 2005. Rail's modal share was 30 percent as of 2008 according to the 2008 Person Trip Survey, an increase from 25 percent in 2003. One of the reasons for the recent increase in rail demand is the development of an urban rail network. Recent changes in the population distribution pattern and sharp increase of gas prices may also influence individuals' modal choice. In any case, the economy of Tokyo is highly reliant on an efficient urban rail network.

Tokyo's urban rail market has unique characteristics. First, many rail services are provided by private rail companies. Each rail company has its own rail infrastructure and rolling stock with its own management system. They are, in essence, monopolistic firms in their own network. Note that one rail company's network may be physically connected directly with another rail company's network, but the service in a rail network is usually operated by the company that owns the rail network. Although they provide rail service monopolistically in their networks, these companies sometimes compete with other rail operators that may also have a rail network connecting the same pair of cities. For instance, Tokyo and Yokohama are connected by three rail lines operated by three different rail companies: JR East, Tokyu Co., and Keikyu Co. Competition between these firms is fierce, and as each rail operator has its own fare table and timetable in addition to its own infrastructure, they attempt to improve their service by improving fares, travel time, and station facilities to obtain more passengers.

Second, the rail network in Tokyo has been developed under the guidance of the central government. Long-term urban rail development plans, so-called "master plans," are made by the central government and have an important role in the decision-making of rail companies. Tokyo's urban rail master plan began in the early twentieth century, and is now over 100 years old (Morichi, 2000). At least ten master plans have been proposed by the government's committee under commissions by the Minister of MLIT. The latest master plan was issued in 2000 in Report No. 18 of the Council for Transport Policy (Morichi et al., 2001). It should be noted that the master plans do not have any statutory basis; a master plan lays out the government's vision regarding the future of the urban rail network in Tokyo, and the government cannot force rail operators to follow it. However, in the long history of the urban rail market in Japan, most rail developments have been implemented voluntarily following the master plans.

Third, Tokyo's rail users have suffered from chronic traffic congestion for many years (Kato et al., 2012). The urban rail demand for commuting increased sharply from the 1960s to the 1980s. This was caused by the constant growth of the working population, which was mainly due to migration from rural areas for job opportunities. Although rail operators tried to increase traffic capacity by investing in new rail lines, increasing service frequency, enhancing station capacity, and introducing high-capacity rolling stock, the speed of demand growth was much higher than that of supply increase. This motivated the government to spotlight a transport policy to reduce traffic congestion, and it also encouraged the evaluation of in-vehicle crowding since the 1980s in Japan.

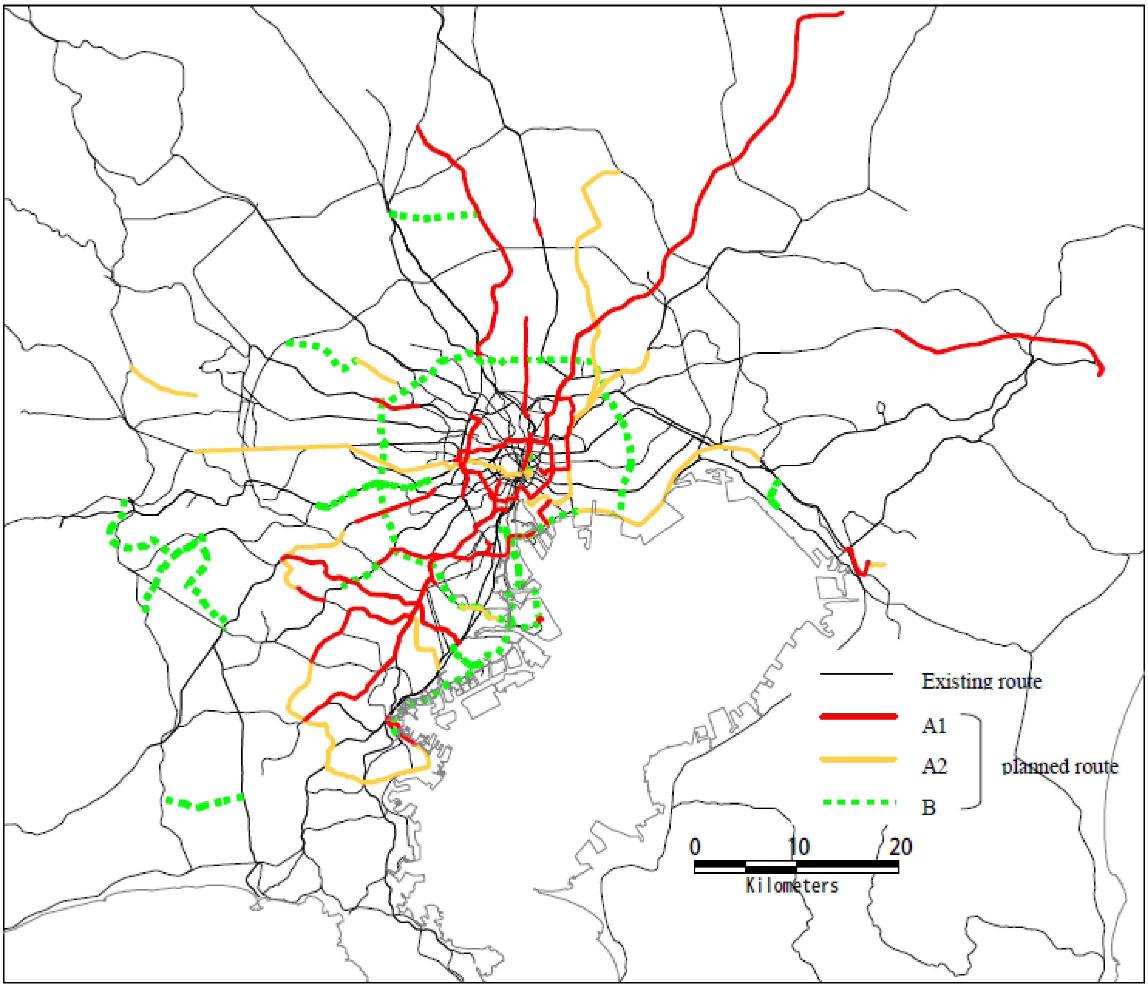
Fourth, a recent demographic trend should be also highlighted in Tokyo: rapid aging. The senior population—those ages 65 and over—comprised eight percent of the Tokyo metropolitan area's population in 1985; in 2005, it was 18 percent, and it is expected to reach 24 percent by 2015. The population of workers is also expected to decrease in the future. This aging issue may be faced by other OECD countries in the near future; thus, the experiences in Tokyo could be very useful for transportation policy there.

3.2. 2000 Urban Rail Development Master Plan for Tokyo

MLIT finalized the 2000 Urban Rail Development Master Plan in January 2000 (Morichi, 2000). This plan presents an ideal picture of the Tokyo Metropolitan Area's urban rail network in 2015 with the necessary rail developments. It identified five major targets to solve the expected problems in Tokyo's urban rail market: "Reduction of in-vehicle crowding," "Saving travel time," "Contribution to urban redevelopment," "Improvement of accessibility to airports and high-speed rail," and "Development of seamless transport network by introducing barrier-free facilities." The first target is a congestion-related policy issue in Tokyo, and has not been solved yet. The government stated that the congestion rate in 31 major rail links should be equal to or lower than 150 percent during morning peak hours. Note the government has regularly monitored in-vehicle traffic congestion in major rail lines in Tokyo. The second target is related to the Tokyo metropolitan area's decentralized land-use policy, in which satellite sub-centers have been developed for business. Saving travel time for rail connections between sub-centers was pursued in addition to saving travel time for commuting from residential areas to business districts. The third target aims to increase rail capacity, particularly in the central business district (CBD) of Tokyo. Since the 1990s, a number of high-rise buildings have been built both for business use and for residential use in the CBD. This is because seaside areas near Tokyo Bay have been redeveloped for business and residential use and because the younger generation has gradually changed its preference for living space from suburban residential areas to the central area. These land-use pattern changes are expected to generate a large traffic volume. The fourth target follows the globalization of business and tourism markets. The government has also implemented a globalization policy that includes the deregulation of the air transportation market and the promotion of tourism in Japan. The improvement of rail access to and from airports and high-speed rail are critical for better business and tourism conditions. Finally, the fifth target reflects the rapid aging of Japanese society. Social participation by seniors is widely understood to have a vitalizing effect on economic activities under the depopulation trend, and easy access to social services could be one of drivers to give them better mobility in urban areas. Thus, the introduction of new devices and upgrades to station facilities for handicapped passengers was highly recommended.

The 2000 Urban Rail Development Master Plan also presented a list of rail development projects that were recommended to implement construction or to study feasibility. The recommended network is depicted in a map shown in Figure 2. The proposed projects are categorized into three types: A1 routes that are suitable for operation by the target year; A2 routes that are suitable for starting development by the target year; and B routes that must be developed or studied in the future. Rail projects in A1 routes are considered the highest priority, which may mean that they are strongly supported by the government. In A1 projects, a consensus among stakeholders has been reached or almost reached; thus, these projects can be started immediately following the completion of the official process. Rail projects in A2 routes are regarded to be middle priority, which means that they are supported by the government but may have some reasons for not being immediately started, such as technical problems in construction or contract problems between different companies. B projects are typically considered important from the viewpoint of government targets, but they may not satisfy necessary conditions such as cost-benefit criteria or financial viability criteria. Thus, further feasibility studies are required. The total length of the proposed projects is 658 km. The length of the A1, A2, and B routes are 288.0 km, 166.8 km, and 203.3 km, respectively.

Figure 2. **Urban Railway Network Master Plan in the Tokyo Metropolitan Area.**



Source: Morichi et al. (2001)

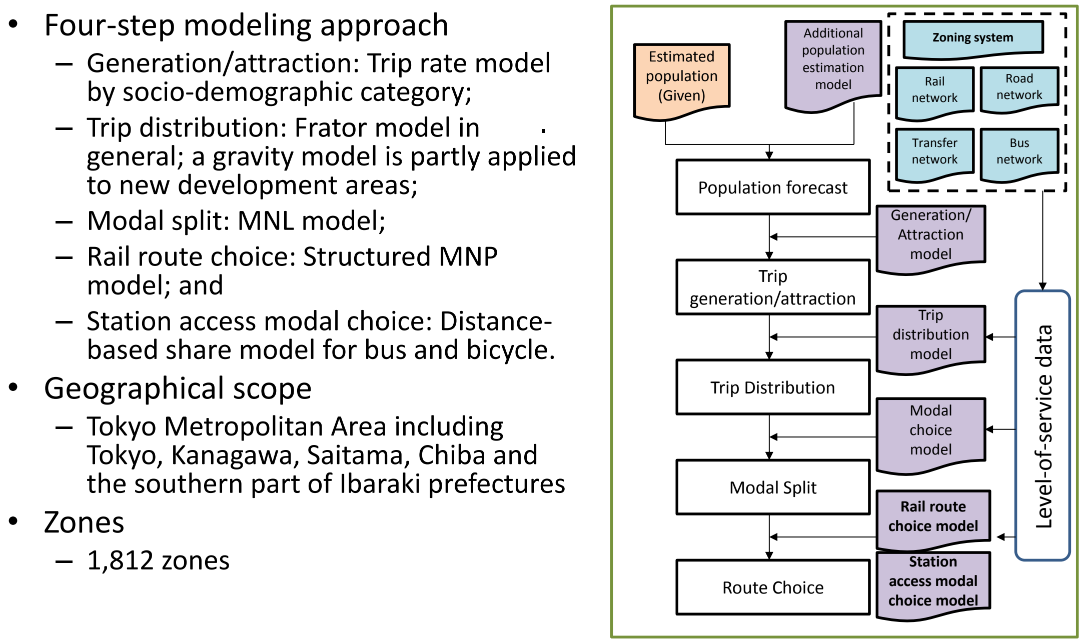
3.3. Rail Demand Analysis and Project Evaluation in the 2000 Urban Rail Development Master Plan for Tokyo

The 2000 Urban Rail Development Master Plan for Tokyo was based on the typical transportation planning process. Future traffic demands of proposed rail lines and the related network were estimated with a traffic demand model, whereas the proposed projects were evaluated both from economic and financial perspectives.

Rail demand modeling and traffic demand forecasts have been included in the master plans for over 30 years. A mathematical travel demand analysis was first introduced into urban rail planning in Tokyo in 1972. In 1985, a four-step travel demand model was introduced into rail demand analysis. Multinomial logit (MNL) models were used for the modal choice and rail route choice models.

In the 2000 Urban Rail Development Master Plan for Tokyo, the four-step travel demand model was again used for travel demand forecasts (Figure 3). The MNL model was used for the modal choice analysis, while a probit-based stochastic user equilibrium (SUE) method was used for the route choice analysis. The probit model is used because it is necessary to incorporate the commonality of routes into the rail route choice analysis. A huge urban rail network with high density has already been developed in the Tokyo metropolitan area. Thus, to avoid an enormous amount of calculation time, the probit model with a structured error component was introduced (Yai et al., 1997). We call this model the "structured probit model." The coefficients are estimated by the simulation method using the Geweke, Hajivassiliou, and Keane (GHK) recursive simulator (Geweke et al., 1994; Train, 2003). The details of the urban rail route choice model in the context of Tokyo have been also studied by Kato et al. (2010a).

Figure 3. Travel Demand Analysis System in the 2000 Urban Rail Development Master Plan for Tokyo



- Four-step modeling approach
  - Generation/attraction: Trip rate model by socio-demographic category;
  - Trip distribution: Frator model in general; a gravity model is partly applied to new development areas;
  - Modal split: MNL model;
  - Rail route choice: Structured MNP model; and
  - Station access modal choice: Distance-based share model for bus and bicycle.
- Geographical scope
  - Tokyo Metropolitan Area including Tokyo, Kanagawa, Saitama, Chiba and the southern part of Ibaraki prefectures
- Zones
  - 1,812 zones

Source: Author

The conventional cost-benefit analysis approach has been used for rail project evaluation. The 2000 Urban Rail Master Plan for Tokyo introduced a systematic cost-benefit analysis for all proposed rail projects. The with-project and without-project cases are defined, and the benefit and cost from the project will be estimated using the estimated traffic demand from the traffic demand forecast. The with-project case assumes the rail network and service under the condition that a new rail service has been introduced in the target year, while the without-project case assumes the current rail network and service in the target year. The benefit consists of the user's benefit, supplier's benefit, and other benefit. The user's benefit is estimated from the expected maximum utility divided by the marginal utility with respect to income, which is equal to the (expected) consumer's surplus. The expected maximum utility is derived from the (indirect) utility function in the rail route choice model, which is estimated in the traffic demand analysis. The supplier's benefit is also estimated with the expected profits of rail users using the estimated results of rail traffic demand. The other benefit is mainly the reduction of environmental impact. The details of the cost-benefit analysis follow the CBA Manual.

3.4. Values of Rail Service Estimated in the 2000 Urban Rail Development Master Plan for Tokyo

Examples of valuing rail service can be provided from the estimation results of the rail route choice model in the 2000 Urban Rail Master Plan for Tokyo. Four rail route choice models were estimated by travel purpose—home-to-work, home-to-school, private, and business—using a sample dataset constructed from the 1995 Tokyo Metropolitan Transport Census (ITPS, 1996). The following variables are used in the linear utility functions: in-vehicle travel time, access and egress travel time, access travel time (only for home-to-school travel), egress travel time (only for home-to-school travel), transfer time (including waiting time), travel cost, and in-vehicle congestion index (only for home-to-work and home-to-school travel). Transfer time means the connection time from one train to another train, which mainly includes walking from one platform to another platform in the same station. The in-vehicle congestion index is defined as follows:

$$CI_{k,ij} = \sum_{pq} \delta_{k,ij,pq} \cdot T_{in-vehicle,k,ij,pq} \cdot \left(\frac{x_{pq}}{cap_{pq}} \right)^2 \tag{13}$$

where

$CI_{k,ij}$ is the in-vehicle congestion index of a rail route k from zone i to zone j;

$\delta_{k,ij,pq}$ is equal to 1 if the link from p to q is included in the rail route k from zone i to zone j and 0 otherwise;

$T_{in-vehicle,k,ij,pq}$ is the in-vehicle travel time of the link from p to q in rail route k from zone i to zone j;

x_{pq} is the traffic flow in the link from p to q; and

cap_{pq} is the traffic capacity in the link from p to q.

This means that the in-vehicle congestion function is assumed to be a quadratic function of the in-vehicle congestion rate. The estimated coefficients of the rail route choice model are shown in Table 5.

Table 5. **Estimation Results of the Rail Route Choice Model**

	Home-to-work	Home-to-school	Private	Business
In-vehicle travel time (min.)	-0.0943 (-8.1)	-0.0597 (-5.8)	-0.0494 (-2.9)	-0.0499 (-3.3)
Access and egress travel time (min.)	-0.127 (-11.7)		-0.0583 (-4.3)	-0.0599 (-5.8)
Access travel time (min.)		-0.0691 (-6.2)		
Egress travel time (min.)		-0.0603 (-5.7)		
Transfer time including waiting time (min.)	-0.112 (-10.7)	-0.0793 (-8.7)	-0.0722 (-4.2)	-0.0687 (-4.5)
Travel cost (JPY)	-0.00200 (-4.0)	-0.00388 (-7.1)	-0.00233 (-3.0)	-0.00103 (-1.6)
In-vehicle congestion index	-0.00869 (-3.3)	-0.00177 (-0.8)		
Ratio of two variances	0.436 (2.7)	0.161 (1.4)	0.513 (1.2)	0.214 (1.1)
Log-likelihood ratio	0.390	0.331	0.172	0.156
Number of observations	1218	811	436	357

Note: Values in parentheses are *t*-statistics.

Source: Morichi et al. (2001)

The estimated values and multipliers of in-vehicle travel time, access/egress travel time, access travel time, egress travel time, and transfer time (including waiting time) are presented in Tables 6 and 7. Table 6 includes the results using both JPY and USD. The currency exchange rate as of November 1995 is used because the original data in the 1995 Metropolitan Transport Census was collected in late autumn.

Table 6. **Rail Service Values Estimated with the Rail Route Choice Model**

	Home-to-work	Home-to-school	Private	Business
In-vehicle travel time	47.2 (0.46)	15.4 (0.15)	21.2 (0.21)	48.4 (0.48)
Access and egress travel	63.5 (0.62)		25.0 (0.25)	58.2 (0.57)
Access travel time		17.8 (0.17)		
Egress travel time		15.5 (0.15)		
Transfer time (including waiting time)	56.0 (0.55)	20.4 (0.20)	31.0 (0.30)	66.7 (0.65)

Note: Units are JPY per min. (USD per min.) as of November 1995 when 1 USD = 101.86 JPY.

Table 7. **Multipliers Estimated with the Rail Route Choice Model**

	Home-to-work	Home-to-school	Private	Business
Access and egress travel time	1.35		1.18	1.20
Access travel time		1.16		
Egress travel time		1.01		
Transfer time (including waiting time)	1.19	1.33	1.46	1.38

Table 7 shows that the estimated multipliers of the value of in-vehicle travel time with respect to access/egress travel time vary from 1.01 to 1.35, whereas those with respect to transfer time vary from 1.19 to 1.46. Compared with the data shown in the CBA Manual, the estimated multipliers are in the range of the multipliers with respect to transfer time by transfer type shown in Table 4. Note that the estimated multipliers with respect to transfer time in Table 7 contain both transfer time and waiting time.

Next, an in-vehicle congestion multiplier is computed with the estimated coefficients in the rail route choice models. A single link is assumed for the computation, although the in-vehicle congestion index is, in general, defined as the sum of the link-based in-vehicle congestion disutility of all links in a given route. This means the in-vehicle congestion multiplier is shown as

$$\alpha_{cong} = 1 + \frac{\hat{\gamma}}{\hat{\beta}} \left(\frac{x}{cap} \right)^2$$

where

α_{cong} is the multiplier with respect to in-vehicle congestion;

$\hat{\gamma}$ is an estimated coefficient with respect to the in-vehicle congestion index; and

$\hat{\beta}$ is an estimated coefficient with respect to in-vehicle travel time.

The in-vehicle congestion multipliers computed for home-to-work and home-to-school travel are depicted in Figure 4.

Figure 4. **Computation Results of In-vehicle Congestion Multipliers with the Multiplier of the CBA Manual.**

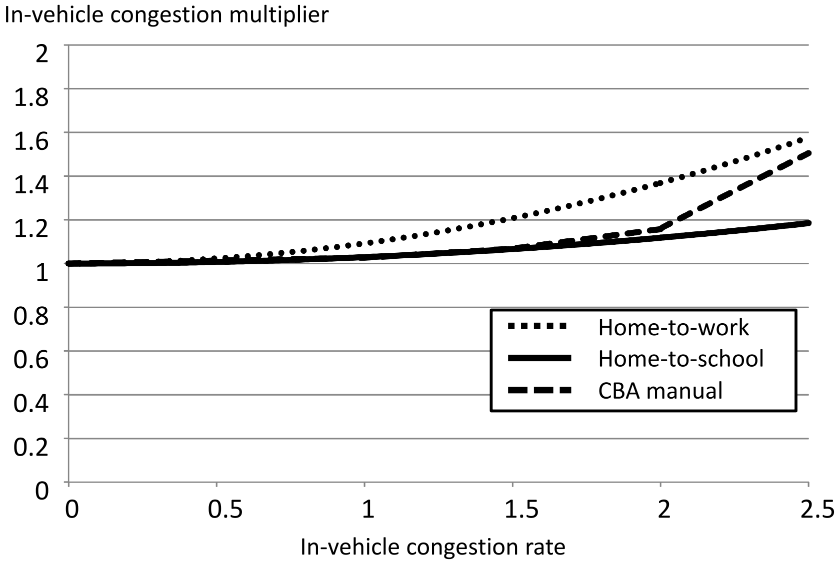


Figure 4 shows that the in-vehicle congestion multiplier increases to approximately 1.6 for home-to-work travel and to approximately 1.2 for home-to-school travel. In contrast, the formula shown in the CBA Manual is nearly equal to the multiplier of home-to-school when the in-vehicle congestion rate is lower than 2, and it sharply rises and becomes close to the multiplier of home-to-work as the in-vehicle congestion rate increases over 2.

CONCLUSIONS

This paper introduced the recent practices of cost-benefit analysis for urban rail investment projects in Japan, particularly focusing on the values of rail service, and showed examples of the valuation of rail service using the case of the 2000 Urban Rail Development Master Plan for Tokyo.

As seen in the CBA Manual for rail projects, the valuation of in-vehicle congestion has been highlighted in Japan for years. This is because the urban rail service has suffered from serious in-vehicle crowding in the urban rail networks of metropolitan areas, including Tokyo. The national government has also raised the issue of the in-vehicle congestion of urban rail networks in its railway development policy for many years; for example, it explicitly set the policy target that average in-vehicle congestion rates in 31 major rail sections in Tokyo should be 150 percent or less. In spite of the government's policy, however, the latest government review found the average in-vehicle congestion rate to be 164 percent as of 2010 (ITPS, 2013). One of the reasons for this is the recent prolonged economic recession, which has made it difficult for private rail operators to further invest in the expansion of traffic capacity.

In addition, the importance of valuating transfers at stations has been recognized in the CBA Manual. This reflects the recent socio-demographic trend in Japan of an aging population. Additionally, the social inclusion of handicapped people has been emphasized in recent years. The national government introduced the Barrier-Free Act in 2000, making the installation of elevators and escalators at large-scale rail stations mandatory. According to the government's review, as of 2010, 77 percent of rail stations whose daily passengers numbered 5,000 or more had installed barrier-free facilities (MLIT, 2011). As the further growth of the number of aged rail users is expected in the coming decade, the national government revised the Act in 2011 with a new policy target: that 100 percent of rail stations whose daily passengers numbered 3,000 or more install the barrier-free facilities.

For the further promotion of comfort and safety improvements in public transportation service, MLIT introduced the "Indexes of Comfortable and Easeful Public Transportation" (ICE-PT) in March 2004 (MLIT, 2004). ICE-PT contains nine indexes for operators in the Tokyo and Osaka metropolitan areas covering both urban rail and buses (see Table 8). MLIT regularly collects statistical data from public transportation operators and provides the indexes to the public every year. MLIT's goal is to monitor the performance of public transportation operators for benchmarking, based on which the government promotes the voluntary-based efforts made by private operators of public transportation service.

Finally, further issues are summarized, particularly in the Japanese context. First, parameters and multipliers in valuing rail service should be regularly monitored and revised. One of the barriers to this is the difficulty of data collection in recent years. Although regular large-scale travel surveys have been implemented in metropolitan areas in Japan, the government’s prolonged financial problems may not guarantee a sustainable travel survey system in the future. Instead of a large-scale RP survey, a stated preference (SP) survey should be considered for estimating the values of rail service as a potential solution. Additionally, an SP survey for valuing rail services in OECD member countries may be helpful for sharing Japan’s skills and experiences.

Table 8. **Definitions of Nine Indexes in “Indexes of Comfortable and Easeful Public Transportation” proposed by MLIT, Japan**

Index	Definition
1. Rail in-vehicle congestion rate during a peak hour	Average hourly rail in-vehicle congestion rate at the most congested rail section during a peak hour
2. Share of step-free station	Share of rail stations with over 5,000 passengers/day that have introduced non-step routes out of stations
3. Share of non-step bus	Share of non-step buses out of total buses
4. In-vehicle comfort index	Share of rail vehicles in which high-performance air conditioners have been installed out of all rail vehicles
5. Availability of rail service information at platforms	Share of station platforms with light-emitting diode (LED) devices installed that display the service schedule, destination, and other information out of all platforms
6. Availability of rail service information in stations	Share of rail stations where display boards and announcement systems are installed to provide information about the type of rail service, destination, etc. out of all stations
7. Availability of rail service information in vehicles	Share of rail vehicles where display boards or announcement systems are installed to provide information about the next stop, etc. out of all vehicles
8. Accessibility of rail passengers to staff at stations	Share of station platforms where station staff are allocated or devices for communication between passengers and rail staff are installed out of all platforms
9. Accessibility of rail passengers to staff in vehicles	Share of rail vehicles where rail staff are allocated or devices for communication between passengers and rail staff are installed out of all vehicles

Source: MLIT

Next, the valuation of more detailed rail service categories may be necessary. For example, the multipliers of rail in-vehicle congestion may vary among different socio-demographic sub-groups such as aged rail users versus young rail users. These have not been explicitly taken into consideration in the CBA Manual, although some studies, such as Kato et al. (2003b), have challenged the empirical analysis. As rapid aging is expected in many OECD member countries, further investigation of multipliers/parameters may be needed and shared among them.

Finally, the comparison of the values of rail service with those of other public transportation services, such as bus service, bus rapid transit, inter-urban transportation, and air transportation, should be explored. The valuation of inter-urban transportation in the context of Japan has been challenged by some studies (e.g., Kato and Onoda, 2009); however, bus service values have not been well analyzed in Japan even though bus service is important in many cities. Evidence from other OECD member countries in valuing other public transportation services may also contribute to the discussion in Japan.

ACKNOWLEDGMENTS

Some data shown in this paper refer to documents used in the Committee on Current Problems and Future Direction of Railway Development in the Tokyo Metropolitan Area. Information about ICE-PT was kindly provided by MLIT, which also provided advice. I am grateful to Mr. Tomoharu Hase (MLIT), Mr. Kasuhiro Kishimoto (MLIT), Mr. Shinichiro Kato (Institute of Transport Policy Studies), Mr. Yoshihisa Yamashita (Creative Research and Planning Co.), and Mr. Satoshi Seki (Tokyu Co.) for their support with the data.

REFERENCES

Ben-Akiva, M. and Lerman, S. (1985) *Discrete Choice Analysis: Theory and Application to Travel Demand*, MIT Press, Cambridge.

Geweke, J., Keane, M. and Runkle, D. (1994) Alternative computational approaches to inference in the multinomial probit model, *The Review of Economics and Statistics*, Vol. 76, No. 4, pp. 609–632.

Ieda, H. (1989) Evaluation of transport congestion in commuter railways and its applications, Presented at the 5th World Conference on Transport Research, Yokohama (Japan), July 1989.

Institution of Transport Policy Studies (1996) *Final Report on Metropolitan Transport Census 1995.* (in Japanese)

Institution of Transport Policy Studies (2000) *Final Report on Project Selection and Feasibility Analysis for Improvement of Rail-related Facilities*, Urban Railway Study in 1999 (General Study). (in Japanese)

Institution of Transport Policy Studies (2008) *Final Report on Metropolitan Transport Survey 2005*. (in Japanese)

Institution of Transport Policy Studies (2013) *Final Report of Research Committee on a Desirable Urban Railway System in the Tokyo Metropolitan Area*. (in Japanese)

Kato, H., Kaneko, Y. and Inoue, S. (2003a) Measurement of transport investment benefit: Empirical comparisons between OD-based approach and route-based approach, *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 5, pp. 2962–2971.

Kato, H., Shikai, J., Kato, S. and Ishida, H. (2003b) Cost-benefit analysis for improvement of transfer service at urban railway stations, World Transport Research: Selected Proceedings of the 9th World Conference on Transport Research.

Kato, H. (2007) Variation of value of travel time savings over travel time in urban commuting: Theoretical and empirical analysis, *Transportation and Traffic Theory 2007: Papers Selected for Presentation at ISTTT17* (Allsop, R. E., Bell, M. G. H. and Heydecker, B. G., eds.), Elsevier, pp. 179–196.

Kato, H. and Onoda, K. (2009) An investigation of whether the value of travel time increases as individuals travel longer: A case study of modal choice of inter-urban travelers in Japan, *Transportation Research Record*, No. 2135, pp. 10–16.

Kato, H., Kaneko, Y. and Inoue, M. (2010a) Comparative analysis of transit assignment: Evidence from urban railway system in the Tokyo Metropolitan Area, *Transportation*, Vol. 37, No. 5, pp. 775–799.

Kato, H., Tanishita, M. and Matsuzaki, T. (2010b) Meta-analysis of value of travel time savings: Evidence from Japan, Proceedings of the 14th World Conference on Transport Research, CD-ROM, Lisbon (Portugal), July 2010.

Kato, H., Sakashita, A., Tsuchiya, T., Oda, T. and Tanishita, M. (2011) Estimation of road user's value of travel time savings using large-scale household survey data from Japan, *Transportation Research Record*, No. 2231, pp. 85–92 .

Kato, H., Kaneko, Y. and Soyama, Y. (2012) Departure time choice of urban rail passenger under unreliable service: Evidence from Tokyo, Proceedings of the International Conference on Advanced Systems for Public Transport 2012 (CASPT 12), Santiago (Chile), July 2012.

Kidokoro, Y. (2004) Cost-benefit analysis for transport networks: Theory and application, *Journal of Transport Economics and Policy*, Vol. 3 8, No. 2, pp. 275–307.

Ministry of Land, Infrastructure, Transport and Tourism, Japan (1998) *Cost-effective Analysis Manual of Railway Projects 1997*. (in Japanese)

Ministry of Land, Infrastructure, Transport and Tourism, Japan (2000) *Cost-effective Analysis Manual of Railway Projects 1999*. (in Japanese)

Ministry of Land, Infrastructure, Transport and Tourism, Japan (2004) *Study on the Improvement of "Comfort and Safety" in Public Transport: Introduction of the Index of Comfortable and Easeful Public Transportation (ICE)*. (in Japanese)

Ministry of Land, Infrastructure, Transport and Tourism, Japan (2005) *Cost-effective Analysis of Railway Projects Manual 2005* (in Japanese).

Ministry of Land, Infrastructure, Transport and Tourism, Japan (2009) *Technical Guidance of Cost-benefit Analysis for Public Project Evaluation*. (in Japanese)

Ministry of Land, Infrastructure, Transport and Tourism, Japan (2011) Partial revision of basic strategy on the promotion of smoothing travels, http://www.mlit.go.jp/common/000141702.pdf, last accessed on January 2014. (in Japanese)

Ministry of Land, Infrastructure, Transport and Tourism, Japan (2012) *Cost-effective Analysis of Railway Projects Manual 2012*. (in Japanese)

Morichi, S. (2000) *History and Future of Urban Rail System in the Tokyo Metropolitan Area*, Institution of Transport Policy Studies. (in Japanese)

Morichi, S., Iwakura, S., Morishige, S., Itoh, M. and Hayasaki, S. (2001) Tokyo metropolitan rail network long-range plan for the 21st century. Presented at the Annual Meeting of Transportation Research Board, Washington D.C., January 2001.

Small, K. A. and Verhoef, E. T. (2007) *The Economics of Urban Transportation*, 2nd edition, Routledge.

Train, K. (2003) *Discrete Choice Methods with Simulation*, Cambridge University Press, Cambridge.

Williams, H. C. W. L. (1977) On the formation of travel demand models and economic evaluation measures of user benefit, *Environment and Planning A*, Vol. 9, pp. 285–344.

Yai, T., Iwakura, S. and Morichi, S. (1997) Multinomial probit with structured covariance for route choice behaviour, *Transportation Research Part B*, Vol. 31, No. 3, pp. 195–208.

Yai, T., Nakagawa, T. and Ishitsuka, J. (1998) Estimation of the multinomial probit model with structured covariance using the simulation method, *Proceedings of JSCE*, No. 604, pp. 11–21. (in Japanese)

International Transport Forum
2 rue André Pascal
75775 Paris Cedex 16
itf.contact@oecd.org
www.internationaltransportforum.org