Submission date: November 15, 2012
Word count 7,510
6,510 words + 4 Tables

Revised Paper

A Meta-Analysis of the Value of Travel Time Savings Incorporating GDP Per Capita: Evidence from Japanese Passenger Travels

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Abstract. This paper conducts a meta-analysis of the value of travel time savings (VTTS) in Japan. The meta-analysis is based on 261 VTTS estimated from 68 peer-reviewed papers on travel behavior in Japan between 1979 and 2003. First, the basic characteristics of VTTS are analyzed on the basis of purpose of travel, weekday or weekend travel, type of data, urban or inter-urban travel, and attributes of travel. Regression analyses are then conducted on all VTTS estimates, together with those of urban travel and inter-urban travel. Our analysis reveals that the VTTS estimated using the stated preference data are lower than those estimated with revealed preference data: (1) the VTTS of business travel is higher than that of home-to-school, private, and leisure travel and (2) the VTTS of access/egress time, wait time, and transfer time are higher than that of in-vehicle time. We also show that the VTTS of inter-urban travel is higher than that of urban travel. In addition, the VTTS elasticity of GDP per capita is estimated to be 0.55.

Keywords. Value of travel time savings, passenger transportation meta-analysis, Japan

INTRODUCTION

The most significant benefit of any investment in transportation is the travel time that the travelers save. The value of travel time savings (VTTS)—the monetary value attached to saving a determined amount of travel time—is widely used to evaluate the benefit of saving travel time. The concept that lies at the heart of the VTTS, that the consumer gains utility not only from the consumption of goods but from time and goods, was first proposed by Becker (*1*) in 1965. This was on the back of the economic theory of time allocation, which had been introduced in the 1960s. Many empirical and theoretical studies have since been conducted on VTTS. Some of the earliest work in this area was conducted by researchers such as Oort (*2*), De Serpa (*3*), and Evans (*4*), who developed a time allocation model in which the consumer's utility is maximized under the constraints of available time and budgets with respect to time and goods consumption. Later, in the late 1970s and 1980s, disaggregate models became the most popular way to conduct an empirical analysis of VTTS. Train and McFadden (*5*), who chose the home-to-workplace trip for their model, show that the conditional indirect utility function formulated in discrete choice theory gives the value of travel time savings as the marginal substitution rate between travel time and travel cost. Truong and Hensher (*6*, *7*) and Bates (*8*) demonstrated that Becker's model and De Serpa's model could be incorporated into the VTTS estimation within the discrete choice model framework. The initial review of value-of-time was first proposed by MVA et al. (*9*). In the 1990s, new experimental data-collection methods, including stated preference (SP) surveys, were introduced to the VTTS arena to supplement the conventional revealed preference (RP) methods. These new methods prompted national value-of-time studies to be conducted in some European countries, including Great Britain, the Netherlands, Norway, Sweden, and Finland, by researchers such as MVA et al. (*9*), the Hague Consulting Group (*10*), Gunn and Rohr (*11*), Pursula and Kurri (*12*), Ramjerdi et al. (*13*), Hague Consulting Group et al. (*14*), Small et al. (*15*), Dillen and Algers (*16*), Gunn et al. (*17*), Hensher (*18*), and Mackie et al. (*19*).

Owing to the emergence of a large number of studies that have provided estimates of the value of travel time, it has recently become possible to conduct meta-analyses of the data on value-of-time. Wardman (*20*-*22*) and Abrantes and Wardman (*23*) reviewed the evidence on the value of travel time in the context of Great Britain. Alongside these meta-analyses, Zamparini and Reggiani (*24*) conducted a meta-analytical estimation of the similarities and the differences between European and North American observations using a selection of empirical studies. Zamparini and Reggiani also investigated the value of freight travel time savings on the basis of a meta-analysis conducted on a sample of empirical observations related to several European and North American countries (*25*). Bickel et al. (*26*) conducted a HEATCO meta-analysis of passenger transport in 25 EU countries and Switzerland on the basis of 77 studies from 30 countries. However, to date, no meta-analysis on the VTTS in Japan has been conducted, other than that of Kato et al. (*27*), despite the fact that a number of empirical studies have analyzed Japanese travel behavior and estimated the VTTS.

In Japan, the benefit of saving travel time in road investment is evaluated with VTTSs based on cost saving approach for both business travels and non-business travels. Although some researchers recommend that the VTTS of non-business travels should be estimated based on willingness-to-pay approach, its approach has not been applied mainly due to the lack of empirical evidences on VTTS in Japan. In addition, the influence of GDP is not incorporated into VTTS estimation in Japan although some countries such as UK and US take it into account in their VTTS guidelines. Thus this study intends to contribute to the evidences of VTTS estimation in Japan.

This paper extends the work of Kato et al. (*27*), which was the first meta-analysis in the context of Japan. Although Kato et al. (*27*) did not include Gross Domestic Product (GDP) as one of their explanatory variables, it is included in this study to evaluate its impact on the VTTS. The studies that are used in our meta-analysis are predominantly those that estimate the VTTS of Japanese travelers using discrete choice models. We include studies that examine urban transportation, as well as those focusing on inter-urban transportation, and we look at studies that discuss modal choice, route choice, and parking choice across Japan. The meta-analysis considers 261 VTTS estimated from 68 refereed papers. Our meta-analysis is based on the development of a regression model to explain variations in the VTTS estimates across studies as a function of important variables. This approach has been shown to be an excellent quantitative method for reviewing scientific studies (*28*–*30*). This approach has also been used in transportation economics. Baaijens et al. (*31*) conducted a meta-analysis of data from 11 tourist studies to examine regional tourist income multipliers. For example, Kremers et al. (*32*) used a meta-analysis to analyze the price elasticity of transportation demand, and Espey (*33*) analyzed gasoline demand using an international meta-analysis of elasticities.

The paper is organized as follows. The current section states the motivations and goals of this paper. The next section describes the data set used in our meta-analysis, shows the results of the descriptive analysis, and presents the results of meta-regression analysis. Then, the implications of the meta-analysis and a comparison with past meta-analyses that have been performed in other countries are presented. Finally, possible directions for further research are proposed.

DATASET

Selection of the Data Set

In conducting our meta-analysis, we reviewed all academic papers concerning our subject that had been peer-reviewed in journals published in Japan. We identified 81 papers that focused on Japan and were published in Japan in a variety of journals, including the Journal of Infrastructure Planning and Management (Japan Society of Civil Engineering (JSCE)), Infrastructure Planning Review (JSCE), Transport Policy Studies' Review (Institute for Transport Policy Studies), Traffic Engineering (Japan Society of Traffic Engineers), and Urban Planning Reviews (City Planning Institute of Japan). Information was collected for each VTTS estimate, including the year of data collection, the associated annual GDP, the season of data collection, the sample size, the type of travel (including whether the travel was urban or inter-urban), [1] attributes of the travel (including whether the travel was in-vehicle/waiting/transfer/access/egress), the choice context, the location where the survey was conducted, the type of data used in the estimation, the purpose of travel, the choice set assumed in the model, the type of model used in the estimation, whether the data applied to a weekday or weekend day, the purpose of the study, and the age of the respondents. Moreover, for each VTTS estimate, the coefficients, corresponding t-statistics, and the likelihood ratio for each estimated model for travel time and travel cost were collected. Each of the papers was then screened as follows. First, we identified those papers that contained all the information necessary to conduct the meta-analysis, and eliminated any papers that exhibited ambiguous information. Second, for all papers that estimated multiple VTTS based on a single sample, we chose one VTTS that we deemed most appropriate. These were the models that were found to have the best fit. It is important to note that the VTTS that were estimated according to different samples were not eliminated, even if they had been estimated by the same authors in the same paper. Third, we selected those VTTS estimates based on models that contained statistically significant coefficients. If travel time or travel cost in the utility function was not found to be significant at a 95% confidence level, then the corresponding VTTS estimates were eliminated. Finally, we eliminated negative VTTS because, as discussed, VTTS estimates made according to discrete choice models are expected to be positive. From this screening process, a sample of 68 academic papers was selected. Data were collected between 1979 and 2003, yielding 261 VTTS estimates.

Characteristics of the Data Set

Of the 68 papers in our data set, 5.9% were specifically concerned with VTTS estimation; these papers account for 8.8% of the total 261 VTTS estimates. Just under 46% (45.6%) of the papers, making up 42.9% of the VTTS estimates, were primarily concerned with policy evaluation or travel demand forecasting. The remaining papers were concerned with providing scientific analyses of travel behavior, analyses that are not intended to be used in practical work. Almost 31% (30.9%) of the 68 papers used data collected in 1979 or during the 1980s, while 55.9% of the papers relied on data collected in the 1990s, and 13.2% used data collected in the 2000s. Just under 68% (67.6%) of the papers, containing 70.1% of the values, were found to refer to urban travel, and 32.4% of the papers, containing 29.9% of the values, referred to inter-urban travel. Of the 261 VTTS estimates, 52.1% were estimated according to data collected on weekdays, while 13.8% were estimated according to data collected on weekends.

TABLE 1 shows the distributions of data with respect to the paper and VTTS estimation from the viewpoints of type of data, choice context, and purpose of travel.

[1] The category of urban travel includes daily travel from a suburban area to a central business district. It predominantly covers home-based travel, such as home-to-workplace and home-to-school travel. The category of inter-urban travel includes long-distance travel between cities or regions. When these studies do not explicitly indicate the type of travel, the travel was categorized according to the distance; when the travel distance was over 100 km, the travel was categorized as the inter-urban.

TABLE 1 Type of Data, Choice Set, Purpose of Travel, Papers, and Valuations

	Papers (%)			Valuations (%)		
	Urban	Inter-urban	Total	Urban	Inter-urban	Total
Type of data						
RP	50.0	86.4	61.8	47.2	89.1	57.5
SP	41.3	9.1	30.9	43.7	6.3	34.5
RP+SP	10.9	4.5	8.8	9.1	4.6	8.0
Choice context						
Modal choice	65.2	54.5	61.8	51.8	48.4	51.0
Route choice	30.4	13.6	25.0	46.2	14.1	38.3
Destination choice	2.2	27.3	10.3	0.5	20.3	5.4
Airport choice	0.0	13.6	4.4	0.0	14.1	3.4
Parking-place choice	4.3	4.5	4.4	1.5	3.1	1.9
Purpose of travel						
Business	2.2	36.4	13.2	1.0	20.3	5.7
Home-to-workplace	26.1	0.0	17.6	20.3	0.0	15.3
Home-to-school	10.9	0.0	7.4	9.1	0.0	6.9
Home-to-workplace and Home-to-school	41.3	0.0	27.9	36.0	0.0	27.2
Private	26.1	27.3	26.5	14.2	14.1	14.2
Leisure	4.3	45.5	17.6	3.6	35.9	11.5
Others	21.7	50.0	30.9	15.8	29.7	19.2

In terms of the data that the individual studies used to analyze the VTTS, 61.8% of the papers used revealed preference (RP) data to estimate the VTTS, while 57.5% of the VTTS were estimated using RP data; just under 31% of the papers (30.9%) used stated preference (SP) data to estimate their VTTS, and 34.5% of the VTTS were estimated using SP data. Almost 9% (8.8%) of the papers used both RP and SP data to estimate their VTTS model, and 8.0% of the VTTS were estimated using an RP/SP combined model. RP data were used more frequently to estimate the VTTS of inter-urban travel than they were for urban travel.

The majority of papers estimated the VTTS in the context of modal choice; 25% analyzed route choice, and 38.3% of the VTTS were estimated according to a route choice model. This reflects the fact that many researchers in Japan are concerned about urban rail routes in large cities, such as Tokyo. This is partly a result of urban rail routes in Japan offering ample opportunities for researchers to observe the trade-off between travel time and cost. Here, 36% of VTTS were estimated for travel between the home and workplace or between the home and school in urban travel, while 1% was estimated for urban business travel. VTTS in the "home-to-workplace and home-to-school" categories are estimated using data on both home-to-workplace travel and home-to-school travel.

TABLE 2 shows the distributions of the types of choice set used when estimating the reviewed papers. Just under 30% (29.4%) of the papers, including 21.5% of the VTTS estimations, used a choice set that included options for "automobile," "rail," and "bus." Almost 26% (26.1%) of the papers that concerned urban travel—including 34.5% of the values in urban travel—were estimated using rail route choice models. The sample size of selected papers ranges from 32 to 15000, and its average is 1382 and median is 811.

ANALYSIS OF DESCRIPTIVE STATISTICS

As the VTTS are estimated for various years, GDP deflators are used to adjust all price levels to the year 2000. **TABLE 3** presents the descriptive statistics for the overall adjusted VTTS. The first aspect to note is that the average VTTS varies depending on the purpose of travel. For instance, the VTTS of business travel is high at 157.7 JPY/minute, which is the highest of the travel types. Although the category of business traveler is likely to include employers and employees, our data unfortunately cannot distinguish between these two groups. However, all VTTS estimates for business travel use RP data. RP data concerning business travel is assumed to be employer's valuation. Therefore, we presume that the resulting valuations of business travel time saved should be a reflection of the employer's valuation of time saved rather than that of employees. The VTTS of home-to-school travel is 11.6 JPY/minute, which, as expected, is the lowest value. The average VTTS of home-to-workplace is 40.9 JPY/minute. It is useful to view the latter average in the context of the average wage rate in Japan in 2000, which was about 41 JPY/minute. Note this is estimated with the data of monthly average income and monthly average work hours, which were collected from firms with five or more workers all over the nation. This means that home-to-workplace travel is nearly the same as the average wage rate. Interestingly, the VTTS of leisure travel is higher than that of home-to-workplace travel. This may be because 25 of the 32 VTTS estimates in leisure travel focused on inter-urban leisure travel. It is widely shown that the VTTS of longer travels such as inter-urban travels tends to be higher than that of shorter travels as discussed later.

The second aspect to note is that the average VTTS on weekdays is 43.4 JPY/minute, while the average VTTS on weekend days is 48.6 JPY/minute. The null hypothesis that the two means are equal is not rejected in this case, as the t-statistic, which tests whether the two means are different, is 0.45. This may mean that the VTTS on weekdays is no different to the VTTS on weekend days. The average VTTS estimated using RP data is 57.1 JPY/minute, while the average VTTS estimated with SP data is 40.6 JPY/minute. The t-statistic that measures the difference between the two means is 2.08, so the null hypothesis that the two means are equal is rejected at the 95% confidence level. This may indicate that the average VTTS estimated using RP data is significantly higher than when using SP data. There is some uncertainty as to whether the average VTTS estimated using combined RP/SP models is more realistic. Four out of the six papers that used combined models—including 16 out of 21 VTTS estimates with RP/SP combined models—conducted scientific analyses of travel behavior, but these were not intended to be used in practical work. The average VTTS of inter-urban travel is 92.5 JPY/minute while the average VTTS of urban travel is 34.1 JPY/minute. The average VTTS of inter-urban travel is significantly higher than that of urban travel. Earlier studies (e.g., Axhausen et al., *34*) have shown that the higher the VTTS, the longer the travel distance. As inter-urban travel is far more likely to require longer travel distances than urban travel, the VTTS of inter-urban travel may also be higher than that of urban travel. The average VTTS of in-vehicle time is 30.3 JPY/minute. The average VTTS of access/egress time, wait time, and transfer time are all higher than the average VTTS of in-vehicle time. The VTTS of access/egress time, wait time, and transfer time are often expressed in units of in-vehicle time. This is because transportation analysts and planners can interpret these values with greater ease, and these values have greater applicability in this context than monetary values. In addition, units of in-vehicle time are significantly more transferable, both spatially and temporally (*20*). In our data-set, The average VTTS, when measured in units of in-vehicle time, are 1.72, 1.20, and 1.26 for access/egress time, wait time at origin station, and transfer time at station, respectively. In his meta-analysis of VTTS in Great Britain, Wardman (*20*) shows that the values of access time, wait time, and walk-and-wait are 1.81, 1.47, and 1.46, respectively. For our purposes, we assume that the station transfer time in the meta-analysis of our Japanese data-set may be regarded as equivalent to the walk-and-wait time in Great Britain. With this assumption, it is clear that the results from Japan are very similar to the results from Great Britain. On the one hand, because the t-statistic, which tests whether the average VTTS of access/egress time is different to that of in-vehicle time, is 1.86, the null hypothesis (hypothesizing that the two means are equal) is rejected at a 90% confidence level. On the other hand, the t-statistics to test whether the average VTTS of wait time and transfer time are different from the average VTTS of in-vehicle time are 0.81 and 1.48 respectively. Therefore, the null hypotheses, in this case, are not rejected. Thus, statistically, the average VTTS of the wait time and transfer time are the same as the average VTTS of in-vehicle time.

REGRESSION ANALYSIS

The models

The following multivariate linear regression model is used for our meta-analysis, based on the work of Wardman (*20*):

$$\ln(VTTS) = \mu + \sum \alpha_i \ln X_i + \sum \beta_j Z_j + \varepsilon \quad (1)$$

where μ denotes a constant, X_i denotes the i th continuous variable, α_i denotes the i th coefficient of the continuous variable, Z_j denotes the j th categorical variable, β_j denotes the j th coefficient of the categorical variable, and ε denotes the error term following a normal distribution.

All categorical variables have the following two possible values:

0, when the related observation does not belong to the subgroup under consideration;

1, when the related observation belongs to the considered subgroup.

The categorical variables are classified into factor variables and dummy variables. The factor variables include the choice context, type of model, age, type of data, type of travel, weekday/weekend day, attribute of travel, research purpose, and whether the travel is urban/inter-urban. Each factor variable contains one to six subgroups. The choice context includes the following subgroups: modal choice, route choice, destination choice, parking location choice, and airport choice. The type of model includes the following: binary logit, multinomial logit model (MNL), mixed logit model (MXL), nested logit model, multinomial probit (MNP), and others.

The ages of those reviewed were categorized as follows: 65 years old or more, under 65 years old, and no data available. The type of data assessed included stated preference data (SP), revealed preference data (RP), and a combination of revealed preference data and stated preference data (RP+SP). The type of travel was categorized as follows: business, home-to-workplace, home-to-school, home-to-workplace and home-to-school, private, leisure, and other. The weekday/weekend day includes weekday, weekend day, and no data available. The attribute of travel includes access/egress time, wait time at origin station, transfer time at station, headway, wait time for parking, in-vehicle time, walk time, and other. The research purpose includes VTTS estimation, policy evaluation, and behavioral analysis. In the regression, baseline subgroups are defined for each factor variable. The factor variables for the baseline subgroups are assumed to be 1 while those for non-baseline variables can have two values (0 or 1). Thus, the regression coefficients of the non-baseline factor variables measure the differences in average VTTS from the hypothetical set of studies characterized by all values of 0 for non-baseline variables and all values of 1 for baseline variables.

TABLE 2 Choice Set, Papers, and Valuations

Choice set	Papers (%)			Valuations (%)		
	Urban	Inter-urban	Total	Urban	Inter-urban	Total
Auto, Rail, Air, Bus	0.0	13.6	4.4	0.0	21.9	5.4
Auto, Rail, Air	0.0	9.0	2.9	0.0	9.4	2.3
Auto, Rail, Bus	26.1	36.4	29.4	21.8	20.3	21.5
Auto, Rail	8.7	13.6	10.3	5.1	9.4	6.1
Auto, Bus, Walk	4.3	0.0	2.9	4.1	0.0	3.1
Rail, Air	0.0	18.2	5.9	0.0	14.1	3.4
Rail, Bus, Walk	2.2	0.0	1.5	8.1	0.0	6.1
Rail, Bus	4.3	0.0	2.9	1.5	0.0	1.1
Bus, Walk	2.2	0.0	1.5	0.5	0.0	0.4
Rail	26.1	0.0	17.6	34.5	0.0	26.1
Air	0.0	18.2	5.9	0.0	7.8	1.9
Bus	2.2	0.0	1.5	1.0	0.0	0.8
Rail, Auto, Park & Ride	6.5	0.0	4.4	16.8	0.0	12.6
Others	19.6	18.2	19.1	7.6	17.1	9.2

TABLE 3 Descriptive Statistics of VTTS Estimates (JPY/minute, 2000-year price)

	Mean	S.D.	S.E.	25%	50%	75%	Obs
Purpose of travel							
Business	157.7	152.9	39.5	61.1	75.9	230.5	15
Home-to-workplace	40.9	30.4	4.8	14.8	38.0	57.8	40
Home-to-school	11.6	5.7	1.3	6.7	11.5	16.0	18
Home-to-workplace and Home-to-school	40.6	32.4	3.8	14.1	31.7	57.9	71
Private	39.2	22.6	3.7	21.1	31.3	60.7	37
Leisure	55.8	66.8	12.2	18.2	32.8	58.9	30
Others	48.6	69.8	9.9	12.7	26.8	55.8	50
Weekday/weekend day							
Weekday	43.4	50.8	4.3	13.4	27.6	59.0	137
Weekend day	48.6	63.2	10.5	14.2	25.8	53.7	36
Type of data							
RP	57.1	71.8	5.9	20.1	36.8	62.2	150
SP	40.6	50.1	5.3	13.0	23.9	56.7	90
RP+SP	20.2	26.5	5.8	6.2	10.7	20.5	21
Urban/inter-urban							
Urban	34.1	27.7	2.0	13.4	24.8	50.1	197
Inter-urban	92.5	107.2	13.4	29.4	58.8	104.6	64
Attribute of travel							
Access/egress time	52.7	81.8	11.8	19.1	32.2	58.3	48
Wait time at origin station	36.6	31.1	7.3	14.2	31.1	46.7	18
Transfer time at station	38.7	21.5	5.4	20.0	33.4	57.1	16
In-vehicle time	30.7	31.5	4.0	11.7	17.5	40.2	63

The dummy variables used were the mode-specific dummy and cross dummy. The mode-specific dummy variable included a subgroup in which the VTTS are estimated according to a model that includes a travel mode in its choice set. For example, when a discrete choice model includes “automobile,” “rail,” and “bus” in its choice set, the dummy of “automobile,” “rail,” and “bus” are equal to 1, while others are equal to 0. The subgroup with respect to cross dummy variable includes VTTS estimates that are made according to a model that includes a combination of travel mode and choice context. In our model, for route choices that include “air transportation,” the destination choice of air transportation and airport choice of air transportation are considered in our model as the cross dummy variables. Given that the dummy variables can only assume two values (0 and 1), the regression coefficients regarding the dummy variables measure the differences in average VTTS from the hypothetical set of studies characterized by the total value of 0 for these dummies.

Finally, only GDP per capita is used for the continuous data. This is the real GDP per capita observed in the year of data collection.

Estimation Results

TABLE 4 presents the result of regression analyses conducted. The adjusted R^2 is found to be 0.65. There are significant variables in the categories of purpose of travel, attribute of travel, research purpose, and mode-specific dummy.

TABLE 4 Estimation Results of Meta-regression Analysis

Variables	Coefficients	Standard error	t-statistics	
Choice context (Baseline is modal choice)				
Route choice	0.35	0.24	1.44	
Destination choice	-0.35	0.38	-0.93	
Parking location choice	0.03	0.46	0.06	
Airport choice	0.13	0.37	0.34	
Type of model (Baseline is binary logit)				
MNL	-0.01	0.19	-0.08	
MXL	0.12	0.38	0.32	
Nested Logit	-0.35	0.22	-1.56	
MNP	-0.34	0.33	-1.02	
Others	-0.09	0.23	-0.40	
Age (Baseline is 65 year-old or more)				
Less than 65 year-old	-0.44	0.38	-1.16	
No data available	-0.42	0.33	-1.26	
Type of data (Baseline is SP)				
RP	0.32	0.19	1.68	
RP+SP	0.20	0.26	0.77	
Purpose of travel (Baseline is business)				
Home-to-workplace	-0.07	0.27	-0.27	
Home-to-school	-1.27	0.31	-4.08	***
Home-to-workplace and -school	-0.32	0.28	-1.17	
Private	-0.72	0.31	-2.27	**
Leisure	-0.72	0.38	-1.90	*
Others	-0.50	0.30	-1.67	*
Weekday/weekend day (Baseline is weekday)				
Weekend day	0.18	0.37	0.48	
No data available	0.32	0.24	1.34	
Attribute of travel (Baseline is total travel time)				
Access/egress time	0.64	0.19	3.28	***
Wait time at origin station	0.71	0.24	2.88	***

Transfer time at station	0.67	0.26	2.56	**
Headway	-0.57	0.29	-1.94	*
Wait time for parking	-0.82	0.38	-2.13	**
In-vehicle time	0.23	0.55	0.42	
Walk time	0.13	0.18	0.70	.
Others	0.31	0.38	0.82	
Research purpose (Baseline is VTTS estimation)				
Policy evaluation	-0.35	0.20	-1.75	*
Behavioral analysis	-0.17	0.22	-0.74	
Urban/Inter-urban (Baseline is urban)				
Inter-urban	0.38	0.29	1.33	
Mode-specific dummy variable				
Rail	0.12	0.22	0.54	
Auto	0.63	0.21	3.00	***
Bus	-0.44	0.19	-2.30	**
Air transport	1.35	0.37	3.63	***
Ferry	-1.09	0.47	-2.30	**
Walk	0.09	0.25	0.36	.
Park & Ride	0.98	0.24	4.02	***
Cross dummy variable				
Air-route choice	-0.64	0.38	-1.66	*
Air-destination choice	0.42	0.53	0.80	
Air-airport choice	0.34	0.89	0.38	
GDP per capita	0.55	0.44	1.25	
Constant	2.48	0.86	2.89	***
Adjusted R^2		0.58		
Number of observations		261		

Note: "***"means significant at the level of 99%, "**" means significant at the level of 95%, and "*" means significant at the level of 90%.

Type of Data

The coefficient of the RP subgroup is found to be positive. This means that a higher VTTS is estimated when using the RP survey data than the SP survey data. This may be a result of the methodological characteristics of SP valuations, as Wardman (*21*) pointed out. He suggested the following four possible explanations for SP valuations being lower than RP valuations: strategic response bias may cause greater sensitivity to cost variation, the respondents' simplified SP task may prompt them to ignore the role of cost in favor of other attributes; ignorance of unrealistic attribute variations in SP exercises may reduce their coefficient estimate, and the possible influence of bias caused by headway in RP models. These points, discussed in the British context, may also apply in the Japanese context.

Purpose of Travel

The coefficients of the subgroups "home-to-school", "private," "leisure," and "other" are significantly negative. This means that the VTTS of the home-to-school, private, and leisure journeys are lower than the VTTS for business travel; the coefficient of home-to-school travel is the lowest. This means that, of the all the purposes of travel, the VTTS of school travel is the lowest. This is due to the fact that most students are very unlikely to pay for their own travel time, since their travel costs are usually paid for by their parents. The results also show that the VTTS of business journeys is higher than the VTTS of home-to-school travel, private travel, and leisure journeys. There are two possible reasons for higher VTTS of business travels. The first is that the majority of the travelers in this category are employers who are traveling for business purposes. As employers are more likely to be on a higher wage rate than other groups of travelers, their VTTS is therefore more likely to be higher. The second is that 12 business VTTS values out of 15 values are those estimated from air transportation-use business journey data. Air transportation users are expected to be higher-income businesspersons; and this may lead to higher VTTS. We compute VTTS values for different purposes of travel using the estimated meta-regression model. This computation is based on the condition which is modal-choice, binary-logit, less than 65 years old, RP, weekday, total travel time, urban and auto-use. The computed VTTSs of business travel, home-to-school travel, private travel, and leisure travel are 40.9, 11.4, 20.0, and 19.9 JPY per minute, respectively. This means that the ratios to the VTTS of business travel are 0.28, 0.49, and 0.49, respectively. These ratios are similar to those that found in meta-analyses in other countries (for example, in Great Brain, *20*). In countries other than Japan, the VTTS of non-business travel is often estimated to be about 50% of the VTTS of business travel (Small and Verhoef, *35*).

Interestingly, the VTTS of "home-to-workplace travel" and the VTTS of "home-to-workplace and home-to–school" are not significantly different to the VTTS of business travel. By using meta-regression model under the same condition we used above, the computed VTTSs of "home-to-workplace travel" and "home-to-workplace and home-to-school travel" are, 38.0, and 29.6 JPY per minute, respectively. This means that the ratios to the VTTS of business travel are 0.93 and 0.72, respectively. The VTTS of "home-to-workplace and home-to-school" is almost identical to the VTTS of home-to-workplace, because there are significantly more commuters than student travelers, in general. There are two possible reasons why there is a high VTTS of home-to-work travel (indeed, it is as high as the VTTS of business travel in Japan). First, there is serious traffic congestion during peak hours in the morning, particularly in urban rail services in large cities. For instance, in Tokyo, the serious in-vehicle congestion of rail service during morning peak hours forces commuters to remain standing in a cramped space for a period of travel time. This may be responsible for the high value of travel time as a commodity for home-to-work travel. The second reason is the unique work time system in Japan. Most companies function around a fixed work time system, in which employees must start their work at a certain time, for instance, 8:30 a.m. This means that many commuters must reach their workplace within tight time constraints, and so their leisure time cannot be adjusted between the morning and another time of a day. If it is assumed, on the back of conventional microeconomic theory, that marginal utility decreases, then the marginal utility with respect to leisure time will be more significant when there is a morning constraint than when there is no morning constraint. This leads to a higher value of travel time as a resource for home-to-work travel.

Attribute of Travel

The coefficients of the subgroups "access/egress time," "wait time at origin station," and "transfer time at station" are significantly positive. In contrast, the coefficient of the subgroup "in-vehicle time" is not significantly different from the total travel time. Although the access/egress travels may include not only walk but also bus- or car-use travels, the dominant travel mode to and from rail stations is walk in the context of Japan. The VTTS of wait time or walk time is higher because the wait or the walk time is likely to be a more tiring or boring way of spending time than time spent in a vehicle. The coefficient of the subgroup "headway" is significantly negative. This may be a reflection of both the effects of convenience and/or wait time at the station and the reliability of the service. The VTTS of headway is probably low as a result of the overall reliability of the public transit service in Japan. If public transport was not as reliable, and the services were more random, then it is likely that the VTTS of headway would be similar to the VTTS of wait time.

Urban/Inter-urban

The coefficient of the subgroup "inter-urban" is positive although it is less significant. This means the VTTS of inter-urban travel is higher than that of urban travel. One of the possible reasons for this is that inter-urban travelers who may use rail or air transportation are business persons who have a high willingness–to-pay to save travel time. The other possible reason is that people tend to spend a longer total travel time in inter-urban rail travel and air-transportation travel than in inter-urban automobile travel. In general, the longer the travel time, the higher is the VTTS. This is because longer travel time reduces the available time for leisure. If it is assumed that the marginal utility with respect to leisure time decreases as leisure time increases, then the reduction of leisure time will lead to higher marginal utility with respect to leisure time. However, it should be noted that individuals may extend their time budget if the travel time is too long. For example, when the leisure time at the destination is too short as a result of the long travel time, then travelers are likely to change their schedule from a one-day trip to an over-night stay trip. In this case, as the time constraint is loosened, the VTTS may be reduced. This case was reported by Kato and Onoda (*36*) in the context of inter-urban transportation in Japan.

GDP per capita

GDP per capita is used as a measure of income. There are some researches focusing on the relation between the VTTS and cross-sectional income in Japan. But inter-temporal income effect has not been researched in Japan. The coefficient of GDP per capita is 0.55 although it is less significantly positive. This means that a higher GDP per capita results in a higher VTTS, and the GDP elasticity of VTTS is 0.55. This is lower than that estimated by the meta-regression analysis of the UK data (*23*). One possible reason for this is that the dataset used in our meta-analysis includes more non-business travel data than the dataset used for the meta-analysis in the UK.

CONCLUSIONS

This paper analyzed the characteristics of the VTTSs of passenger transportation in Japan. The meta-analysis used regression models to conduct an empirical analysis of data garnered from past papers that estimated the VTTS published in Japanese journals. This is the first meta-analysis that has been conducted on VTTS in Japan using the GDP per capita as one of the explanatory variables. Some of the results that emerged from our meta-analysis are similar to results from meta-analyses in other countries. For example, in our meta-analysis of Japanese data, the VTTS estimated using RP survey data is higher than that estimated with SP survey data. This result was also found in Wardman's meta-analysis of the VTTS in Great Britain (*21*). However, our meta-analysis has also revealed findings that are unique to our study. For example, our meta-analysis indicates that the VTTS of home-to-work travel is similar to the VTTS of business travel. This differs from the VTTS evidence in the British context, in which business travel has a higher VTTS than non-business travel (*22*). This disparity may be accounted for by the unique conditions of the Japanese work system. Our analysis also presented the impact of GDP per capita on the VTTS. It shows that the GDP per capita may positively affect the VTTS. This is consistent with past studies in UK (*23*). However, the VTTS elasticity of GDP per capita is 0.55, which is smaller than that estimated from the UK data.

There are some limitations to our study that further research would benefit from considering. First, the data used in our analysis is garnered only from refereed academic papers. Although the quality of the data is guaranteed, the sample size of our data is still relatively small. Since other studies on this subject have been published in technical reports rather than in academic journals, a richer analysis may be possible if the data from these studies is incorporated into this meta-analysis. Second, our meta-analysis does not consider certain important issues. Many of these issues have been analyzed in past research in this area. For example, journey distance is not included in our analysis, data regarding journey distance is not available in our data set. Finally, further research would benefit from considering the value of freight travel time saving (VFTTS). However, as the number of studies that have been attempted VFTTS estimates in Japan is quite small, incorporating these data into the meta-analysis will be challenging at present. We suggest that further research be conducted in this area to derive a more complete and holistic development of our meta-analysis.

ACKNOWLEDGEMENTS

This research was financially supported by the Grant-in-aid for the Scientific Research of the Japan Society for the Promotion of Science and the research project of Japan Road Technology Convention under the Ministry of Land, Infrastructure, Transport, and Tourism of Japan. We thank Mr. Shio Hayasaki (Social System, Co.) for collecting the data.

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