META-ANALYSIS OF VALUE OF TRAVEL TIME SAVINGS: EVIDENCE FROM JAPAN

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ABSTRACT

This paper examines the value of travel time saving (VTTS) in Japan with a meta-analysis. 216 VTTSs estimated in 68 peer-reviewed papers on travel behavior in Japan from 1979 to 2003 are used for the meta-analysis. First, the basic characteristics of VTTSs are analyzed from the viewpoints of purpose of travel, weekday/ weekend day, type of data, urban/inter-urban, and attribute of travel. Then, the regression analyses are conducted with all VTTS estimates, with VTTS estimates of urban travels, and VTTS estimates of inter-urban travels. The estimation results show that the VTTS estimated with stated preference data is lower than the VTTS estimated with revealed preference data; the VTTS of business travel is higher than the VTTSs of home-to-school, private, and leisure travels; the VTTSs of access/egress time, wait time, and transfer time are higher than the VTTS of in-vehicle time. They also show that the VTTS on weekdays is not significantly different from that on weekend days; The VTTS of urban travel is not significantly different from that of inter-urban travel. In terms of travel mode, the characteristics depend on whether it is urban travel or inter-urban travel.

Keywords: Value of travel time saving, passenger transportation meta-analysis, Japan

1. INTRODUCTION

The dominant benefit component of a transportation investment is a travel time saving. The value of travel time saving (VTTS) is widely used to evaluate the benefit of travel time saving. There have been many empirical and theoretical studies on the VTTS after the economic theory of time allocation was introduced in the 1960s. It was Becker (1965) who first suggested that a consumer gains utility only from the consumption of time and not from the goods consumed directly. After Becker's work, several researchers such as Oort (1969), DeSerpa (1971), and Evans (1972) have developed the time allocation model in which the consumer's utility is maximized with respect to time and goods consumption under the constraints of the available time and money budgets. Then, in the late 1970s and 1980s, the disaggregate models became the most popular approach taken for empirical analysis of VTTS. Train and McFadden (1978) using the choice of mode for the home to workplace trip, show that the conditional indirect utility function formulated in discrete choice theory will give the value of travel time savings as the marginal substitution rate between travel time and travel cost. In similar manner, Truong and Hensher (1985) and later discussions (Bates, 1987; Truong and Hensher, 1987) show how Becker's model and DeSerpa's model can be incorporated into the VTTS estimation within the discrete choice model framework. It was MVA et al. (1987) that had the initial review study of value-of-time. They reviewed a few studies available against which to compare its results. Then, in the 1990s, the experimental data collection methods including Stated Preference (SP) survey was introduced in addition to the conventional Revealed Preference (RP) methods. National value-of-time studies have been conducted in some European countries including Great Britain, the Netherlands, Norway, Sweden, and Finland, including MVA et al. (1987), Hague Consulting Group (1990), Gunn and Rohr (1996), Pursula and Kurri (1996), Ramjerdi et al. (1997), Hague Consulting Group et al. (1999), Small et al. (1999), Dillen and Algers (1999), Gunn et al. (1999), Hensher (2001), and Mackie et al. (2003). On the basis of a very large number of studies that provide estimates of the value of travel time, the meta-analyses of value-of-time have started. Wardman (1998; 2001; 2004) presented the review of British evidence regarding the value of travel time. Zamparini and Reggiani (2007a; 2007b) compared the estimated value of travel time among European and North American countries. Bickel et al. (2006) show the results of HEATCO meta-analysis based on 77 studies from 30 countries for passenger transport in EU 25 countries and Switzerland. However, no meta-analysis on the VTTS has been reported in Japan although a number of empirical studies analyzed the travel behaviors and estimated the VTTSs.

This paper adds new evidence to the body of research related to meta-analysis in the context of Japan. The studies that estimate the VTTS of Japanese travelers mainly with the discrete choice models are used for our meta-analysis. They include the studies of urban transportation as well as inter-urban transportation. They cover the modal choice, route choice, parking choice, etc. 261 VTTSs estimated in 68 refereed papers are considered for the analysis. This is the first trial of meta-analysis of VTTS in Japan.

Our approach is 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 devised as a quantitative method for a review of scientific studies (Huterm and Schmidt, 2004; Kulinskaya et al., 2008; Rosenthal and Di Matteo, 2001). In transportation economics, there are some applications of this approach. Baaijens et al. (1997) used the meta-analysis to study the regional tourist income multipliers; Kremers et al. (2002) used the meta-analysis to analyze the price elasticities of transportation demand; Espey (1998) analyzes the gasoline demands by using an international meta-analysis of elasticities. As far as VTTS is concerned, Wardman (1998) performed the meta-analysis of VTTS with a large number of studies conducted in Great Britain for various attributes related to individual trips; Wardman (2004) shows the meta-analysis of public transport values of time with the studies conducted in Great Britain; Zamparini and Reggiani (2007a) provides a meta-analytical estimation of a selection of empirical studies, emphasizing the similarities and the differences between European and North-American observations; Zamparini and Reggiani (2007b) investigated the value of freight travel time savings based on meta-analysis of a sample of empirical observations related to several European and North American countries.

The paper is organized as follows. Section 1 presents the motivations and goals of this paper. Section 2 shows the data set used in the meta-analysis. In Sections 3 and 4, the results of meta-analysis are shown with the method used in the analysis. The findings are discussed on the basis of estimated results in Section 5. Finally, the implications are shown in comparison with the past meta-analysis in other countries and further research issues are presented.

2. DATA SET

We reviewed the academic papers that were all peer-reviewed in the journals published in Japan. They include 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); Urban Planning Reviews (City Planning Institute of Japan). The data used in those papers were all collected in Japan. 81 academic papers were collected. Then, for each VTTS estimate, corresponding information was collected including the year of data collection; associated annual GDP; the season of data collection; sample size; the types of travel including urban travel or inter-urban travel [1], attributes of travels including in-vehicle/waiting/transfer/access/egress; choice context; the location where the survey was conducted; the type of data used in estimation; purpose of travel; the choice set assumed in model; the type of model used in estimation; weekday or weekend day; purpose of study; and age of respondents. Moreover, the coefficients and corresponding t-statistics in the estimated models for travel time and travel cost as well as likelihood ratio were collected for each VTTS estimate.

[1] The urban travel includes the daily travels from sub-urban area to central business district. It mainly covers home-based travels such as home-to-workplace and home-to-school travels. The inter-urban travel includes long-distance travels between cities or regions. When the studies do not indicate the type of travel explicitly, we categorized them by its distance. When the travel distance is over 100km, it is categorized as the inter-urban travel.

Then, we screened the papers in the following steps. In the first step, we selected the papers containing all the pieces of information necessary for the meta-analysis from the entire set of available VTTS papers. Additionally, the papers that displayed ambiguous information were eliminated. In the second step, we chose a single VTTS from the papers that estimated multiple VTTSs based on a single sample. We chose a VTTS from such papers that is estimated with the model obtaining the best fitness among models. Note that the VTTSs estimated with the different samples were not eliminated even if they are estimated by the same authors in a same paper. In the third step, we selected the VTTSs that were estimated with the models which contain the significant coefficients statistically. If travel time or travel cost in the utility function is not significant at 95 per cent confidence level, the corresponding VTTS estimates were eliminated. In the final step, we also eliminated the negative VTTSs. This is because the VTTS estimated with the discrete choice models are expectedly positive from the theoretical viewpoint as shown earlier.

On the basis of the above-mentioned considerations, a sample of 68 academic papers where the data were collected between 1979 and 2003 was selected, and these yielded 261 VTTSs.

3. ANALYSIS OF DESCRIPTIVE STATISTICS

As the VTTSs are estimated in various years, they are adjusted into the price level in 2000 by using GDP deflators. Table 1 presents descriptive statistics for the overall adjusted VTTSs. First, the average VTTSs vary among purposes of travel. The VTTS of business travel is 157.7 yen/minute, the highest among travel types. Although the business travelers may include employers and employees, our data cannot distinguish the one from the other unfortunately. However, all VTTSs of business travel are estimated with RP data, we expect that the resulting valuations should be a reflection of the employer's valuation of time saved rather than the employees'. The VTTS of home-to-school travel is 11.6 yen/minute, the lowest. This may be very reasonable. The average VTTS of home-to-workplace is 40.9 yen/minute. Note that the average wage rate in Japan in 2000 is about 30.0 yen/minute. Interestingly, the VTTS of leisure travel is higher than that of home-to-workplace. This may be because 25 out of 32 VTTS estimates in leisure travels are inter-urban leisure travel.

Second, the average VTTS on weekdays is 43.4 yen/minute while the average VTTS on weekend days is 48.6 yen/minute. As the t statistic to test whether the two means are different is 0.456, the null hypothesis that the means of two means are equal is not rejected. This may mean the VTTS on weekdays is indifferent from the VTTS on weekend days.

Third, the average VTTS estimated with RP data is 57.1 yen/minute while the average VTTS estimated with SP data is 40.6 yen/minute. As the t statistic to test whether the two means are different is 2.08, the null hypothesis that the means of two means are equal is rejected at 95 per cent confidence level. This may mean the average VTTS estimated with RP data is significantly higher than the average VTTS estimated with SP data. There is some uncertainty as to whether the average VTTS estimated with RP/SP combined models actually represents the reality. 4 out of 6 papers, including 16 out of 21 VTTS estimates with RP/SP combined models were concerned with the scientific analysis on travel behavior, which are not intended to be used in practical work.

Fourth, the average VTTS of inter-urban travel is 92.5 yen/minute while the average VTTS of urban travel is 34.1 yen/minute. The average VTTS of inter-urban travel is obviously higher than the average VTTS of urban travel. Earlier studies show that the higher the VTTS is, the longer the travel distance is (For example, Axhausen, et al., 2008). As the inter-urban travel requires expectedly longer travel distance than the urban travel, the VTTS of inter-urban travel may be also higher than that of urban travel.

Fifth, the average VTTS of in-vehicle time is 30.3 yen/minute, which is almost equivalent to the average wage rate in Japan as of 2000. The average VTTSs of access/egress time, wait time, and transfer time are higher than the average VTTS of in-vehicle time. The VTTSs are often expressed in units of in-vehicle time because transportation analysts and planners can more readily interpret such values than monetary values and they are also more transferable both spatially and temporally (Wardman, 2001). The average VTTSs in units of in-vehicle time are 1.74, 1.21, and 1.28 in access/egress time, wait time at origin station, and transfer time at station respectively. In the meta-analysis of Great Britain, Wardman (2001) shows that the values of access time, wait time, and walk and wait are 1.81, 1.47, and 1.46 respectively. The transfer time at station may be regarded to be equivalent to the walk and wait time. Then, the results in Japan seem very similar to the results in Great Britain. On the one hand, as the t statistic to test whether the average VTTS of access/egress time is different from that of in-vehicle time is 1.80, the null hypothesis that the means of two means are equal is rejected at 90 per cent confidence level. On the other hand, as the t statistics to test whether the average VTTSs of wait time and transfer time are different from the average VTTS of in-vehicle time are 0.75 and 1.26 respectively, the null hypotheses that the means of two means are equal are not rejected. Thus, from the statistical viewpoints, the average VTTSs of the wait time and transfer time are not different from the average VTTS of in-vehicle time.

Table 1 – Descriptive statistics of VTTS estimates (yen/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 -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	24.8	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	30.3	31.1	3.9	11.8	17.5	39.4	65

4. REGRESSION ANALYSIS

4.1 The models

The following multivariate linear regression model is used for meta-analysis:

$$\log(VTTS) = \mu + \sum \alpha_i Z_i + \varepsilon \quad (1)$$

where μ denotes a constant; Z_i denotes the i th explanatory variable; α_i denotes the i th coefficient; and ε denotes the error term following the normal distribution.
The explanatory variables are all categorical. Each variable has the following two possible values:
-- 0, if the related observation does not belong to the considered subgroup;
-- 1, if the related observation belongs to the considered subgroup.
The variables are classified into factor variables and dummy variables. First, 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 urban/inter-urban. Each factor variable has one to six subgroups in it. The choice context includes the subgroups of modal choice, route choice, destination choice, parking location choice, and airport choice. The type of model includes binary logit, multinomial logit model (MNL), mixed logit model (MXL), nested logit model, multinomial probit (MNP), and others. The age includes 65 year-old or more, less than 65 year-old and no data available. The type of data includes 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 includes business, home-to-workplace, home-to-school, home-to-workplace and -school, private, leisure and others. 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, parking time, in-vehicle time, walk time, and others. The research purpose includes VTTS estimation, policy evaluation, and behavioral analysis. In the regression, baseline subgroups are defined for each factor. The meaning of baseline subgroup is explained as follows. Suppose baseline variables and corresponding coefficients in each factor variable. Note that the baseline variables can also have only two values (0 and 1). Then, the regression analysis with the factor variables means that the baseline variables are assumed to be 1 in regression. Thus, the regression coefficients regarding the factor variables measure the differences in average VTTS from the hypothetical set of studies characterized by all value of 1 of the baseline variables.

Next, the dummy variables include the mode-specific dummy and cross dummy. The subgroup with respect to mode specific dummy variable includes the VTTS that are estimated with a model including 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 the VTTS that are estimated with a model including a combination of travel mode and the choice context. The route choice of 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 all value of 0 of these dummies. As the "baseline VTTS" is introduced to the factor variables, exactly to say, the dummy variables actually measure the differences in average VTTS from the baseline VTTS characterized by all values of 1 of the hypothetical baseline variables as well as by all values of 0 of the hypothetical dummy variables.

Ordinary least square (OLS) and weighted least square (WLS) are examined for regression analysis (Green, 2008). The OLS regression assumes that the variance of residual error should be constant for all values of the independent(s). If the independent(s) has/have different error variance at different ranges of their values, then the estimates of the regression coefficients will have unduly large standard errors for some ranges of the dependent and too small for other ranges. This will reduce the power of significance tests. The WLS regression compensates for violation of the homoscedasticity assumption by weighting cases differentially. As the weight parameter, we used the asymptotic t statistic for VTTS, which is estimated from the estimated coefficients and t-statistics of travel time and travel cost by following the method shown by Armstrong et al. (2001).

4.2. Estimation results

4.2.1 Regressions with all VTTS estimates

Tables 2 presents the results of regression analyses by using all VTTS estimates. First, the adjusted R^2 is 0.57 in OLS regression while it is 0.66 in WLS regression. R^2 in WLS regression is better than the one in OLS regression probably because there may be heteroscedasticity in the VTTS data. Note, however, that the heteroscedasticity is not significant by the statistical test.

Second, the coefficient of subgroup "RP" is significantly positive in OLS regression. This means that the VTTS estimated with RP survey data is higher than that estimated with SP survey data. This may be first because of the methodological characteristics of SP valuations as Wardman (2001) pointed out. He showed the following four possible explanations for SP valuations being lower than RP valuations: strategic response bias causes greater sensitivity to cost variation; simplified SP task for respondents makes them ignore cost than other attributes; ignorance of attribute variations which are no realistic in SP exercises reduces their coefficient estimate; and the bias caused by headway in RP models. They may be also the cases in our context. Additionally, in the context of urban commuting travel in Japan, the commuters do not mind the travel cost much because they are usually compensated for their travel expenses as an additional salary from their employers in Japan.

Third, the coefficient of subgroup "home-to-school" travel is significantly negative in both regressions. The coefficients of subgroups "private", "leisure", and "others" travels are significantly negative in OLS regression. They mean that the VTTSs of the home-to-school, private, and leisure travels are lower than business travel. The coefficient of home-to-school travel is the lowest. This means that the VTTS of school travel is the lowest among purposes of travel. This is because the students have low willingness to pay for saving travel time since they usually owe their travel cost to their parents.

Fourth, the coefficients of subgroups "access/egress time", "wait time at origin station", and "transfer time at station" are significantly positive in both regressions. These mean that the VTTSs of access/egress time, wait time, and transfer time are higher than the VTTS of total travel time. Note that the total travel time means the travel time including all attributes of travels from an origin to a destination. On the other hand, the coefficient of subgroup "in-vehicle time" is not significantly different from the total travel time. Thus, it may mean that the VTTSs of access/egress time, wait time, and transfer time are higher than the VTTS of in-vehicle time. The VTTS of wait time or walk time is higher because the wait or the walk time gives more fatigue or boredom to travelers than in-vehicle time. Next, the coefficient of subgroup "parking time" is significantly negative in both regressions. This means that the VTTS of parking is lower than the VTTS of total travel time. This is reasonable because the parking time in an automobile is more comfortable than walk/wait time. The coefficient of subgroup "headway" is significantly negative in OLS regression. This means that VTTS of the headway in public transit service is lower than the VTTS of total travel time. This may reflect not only the effects of convenience and/or wait time at station but also the reliability of service. The VTTS of headway is low probably because the public transit service is reliable in Japan. Otherwise, the VTTS of headway should be similar to the VTTS of wait time if arrivals for services are random.

Fifth, the coefficients of subgroups "automobile", "air transportation", and "park & ride" are significantly positive in both regressions. This means that the VTTS estimated with a model including automobile, air transportation, or park & ride in its choice set is higher than the baseline VTTS estimate. The coefficients of subgroups "bus" and "ferry" are significantly negative in OLS regression. This means that the VTTS estimated with the model including bus in its choice set is lower than the baseline VTTS estimate. Then, it is summarized that the VTTSs estimated with the model including automobile, air transportation, and park & ride are higher than the VTTSs estimated with a model including bus and ferry. This probably reflects the income level or wage rate of travelers. Those who have automobile or air transportation in their choice set have higher willingness to pay for saving travel time than those who do not have. Moreover, the coefficient of "air transportation" is the highest among travel modes. This means that the VTTS estimated with the model including air transportation in its choice set is the highest. This may reflect that the travelers who possibly choose air transportation have higher willingness to pay for saving time, such as business man, than others.

4.2.2 Regressions with VTTS estimates of urban travel

Tables 3 presents the results of regression analyses by using VTTS estimates of urban travel. The adjusted R^2 is 0.61 in OLS regression while it is 0.67 in WLS regression. These results are slightly better than the regressions with all VTTS estimates. First, the coefficient of subgroup "route choice" is significantly positive in both regressions. This means that the VTTS estimated with route choice model is higher than the VTTS estimated with modal choice model. The coefficients of subgroups "destination choice" and "parking location choice" are significantly negative in both regressions. This means the VTTSs estimated with destination choice model or parking location choice model is lower than the VTTS estimated with modal choice model. The possible reason for higher VTTS in route choice model is because many of route choice models were estimated in the urban rail network of the Tokyo Metropolitan Area. The wage rate in Tokyo is higher than that in other regions in Japan.

Second, the coefficient of subgroup "MNP" is significantly negative in both regressions while the coefficient of subgroup "others" is significantly positive in both regressions. The reason for these is not sure.

Third, the coefficient of subgroup "home-to-school" is significantly negative in OLS regression. This is the same result as the regression with all VTTS estimates.

Fourth, the coefficients of subgroups "access/egress time", "wait time at origin station", and "transfer time at station" are significantly positive. The coefficient of subgroup "headway" is significantly negative in OLS regression. These are the same results as the regression with all VTTS estimates.

Fifth, the coefficient of subgroup "public evaluation" is significantly negative at 95 per cent confidence level in OLS regression while it is significantly positive at 90 per cent confidence level in WLS regression. The reason for the different sign between two regressions is not sure. The coefficient of subgroup "behavioral analysis" is significantly positive in WLS regression. This means that the VTTS in the paper which is concerned with behavioral analysis is higher than the VTTS in the paper which is concerned with VTTS estimation. This is partly because the studies which intend to estimate VTTS may prefer lower VTTS. This may reflect the political pressure on researchers for suppressing the VTTS in the context of Japan.

4.2.3 Regressions with VTTS estimates of inter-urban travels

Tables 4 presents the results of regression analyses by using VTTS estimates of inter-urban travel. First, the adjusted R^2 is 0.89 in OLS regression while it is 0.95 in WLS regression. These are much higher than the regressions of urban travels.

Second, the coefficient of subgroup “destination choice” is significantly positive in both regressions. The reason for it is not sure.

Third, the coefficient of subgroup “MNL” is significantly positive in both regressions. The coefficients of subgroups “MXL”, “MNP” are significantly positive in OLS regression while the coefficient of subgroup “others” is significantly negative.

Fourth, the coefficients of subgroups “access/egress time” and “in-vehicle time” are significantly positive in both regressions. This means that the VTTSs of access/egress time and in-vehicle time are higher than the VTTS of total travel time. The VTTS of in-vehicle time is higher than the VTTS of access/egress time. This may be because of disutility generated from travel time. The in-vehicle hours are much longer than the access/egress time in inter-urban travels. The earlier studies show that longer distance means higher VTTS.

Fifth, the coefficients of subgroups “policy evaluation” and “behavioral analysis” are significantly positive in both regressions. As discussed earlier, this may reflect the political pressure on researchers for suppressing the VTTS in the context of Japan.

Sixth, the coefficient of subgroup “rail” is significantly positive in both regressions. The coefficient of subgroup of “air transportation” is significantly positive in WLS regression. On the other hand, the coefficient of subgroup “auto” is significantly negative in OLS regression. These mean that the VTTSs estimated with a model including the rail or air transportation in its choice set are higher than the baseline VTTS while the VTTS estimated with a model including automobile in its choice set is lower than the baseline VTTS. This may be because the inter-urban travelers who may use the rail or air transportation are business persons who have high willingness to pay for saving travel time.

Table 2 – Estimation results with all VTTS estimates

	OLS regression			WLS regression		
Variables	Coefficients	t-statistics		Coefficients	t-statistics	
Choice context (Baseline is modal choice)						
Route choice	0.31	1.28		0.44	1.36	
Destination choice	–0.44	–1.17		–0.08	–0.19	
Parking location choice	0.14	0.37		0.04	0.07	
Airport choice	–0.05	–0.11		0.61	1.37	
Type of model (Baseline is binary logit)						
MNL	0.12	0.63		0.04	0.15	
MXL	0.11	0.30		1.13	1.57	
Nested Logit	–0.32	–1.44		–0.39	–1.40	
MNP	–0.34	–1.04		0.20	0.46	
Others	–0.08	–0.34		0.47	1.43	
Age (Baseline is 65 year-old or more)						
Less than 65 year-old	–0.44	–1.15		–1.05	–1.45	
No data available	–0.45	–1.34		–0.94	–1.47	
Type of data (Baseline is SP)						
RP	0.40	2.11	**	0.11	0.48	
RP+SP	0.21	0.81		0.22	0.74	
Purpose of travel (Baseline is business)						
Home-to-workplace	–0.07	–0.25		–0.39	–0.80	
Home-to-school	–1.19	–3.81	***	–1.09	–2.20	**
Home-to-workplace and -school	–0.28	–1.00		–0.22	–0.46	
Private	–0.66	–2.11	**	–0.00	–0.01	
Leisure	–0.69	–1.82	*	–0.29	0.44	
Others	–0.49	–1.68	*	0.63	–1.13	
Weekday/weekend day (Baseline is weekday)						
Weekend day	0.17	0.47		–0.85	–1.52	
No data available	0.29	1.25		–0.12	–0.34	

Table 2 – Estimation results with all VTTS estimates (continued)

Attribute of travel (Baseline is total travel time)						
Access/egress time	0.63	3.17	***	1.22	5.20	***
Wait time at origin station	0.73	3.01	***	1.03	3.42	***
Transfer time at station	0.68	2.57	**	1.41	4.34	***
Headway	–0.65	–2.26	**	0.02	0.10	
Parking time	–0.83	–2.14	**	–0.68	–1.83	*
In-vehicle time	0.11	0.60		0.29	1.41	
Walk time	0.33	0.87		0.66	1.54	
Others	0.34	0.62		0.59	0.76	
Research purpose (Baseline is VTTS estimation)						
Policy evaluation	–0.08	–0.43		0.75	3.20	***
Behavioral analysis	0.10	0.52		0.55	1.88	*
Urban/Inter-urban (Baseline is urban)						
Inter-urban	0.43	1.47		0.68	1.87	*
Mode-specific dummy variable						
Rail	0.08	0.38		0.10	0.41	
Auto	0.62	2.88	***	0.68	2.20	**
Bus	–0.52	–2.93	***	–0.14	–0.60	
Air transport	1.39	3.67	***	1.50	2.62	***
Ferry	–1.12	–2.31	**	–0.14	–0.23	
Walk	0.12	0.48		0.15	0.59	
Park & Ride	1.04	4.36	***	1.26	3.70	***
Cross dummy variable						
Air-route choice	–0.76	–1.91	*	–0.11	–0.18	
Air-destination choice	0.27	0.51		0.41	0.54	
Air-airport choice	0.11	0.12		1.38	0.40	
Constant	2.95	5.75	***	2.11	2.58	***
R^2		0.57			0.66	
Number of observations		245			245	

Table 3 – Estimation results with VTTS estimates of urban travels

	OLS regression			WLS regression		
Variables	Coefficients	t-statistics		Coefficients	t-statistics	
Choice context (Baseline is modal choice)						
Route choice	0.68	2.53	**	1.21	3.59	***
Destination choice	–2.36	–2.81	***	–3.09	–4.50	***
Parking location choice	–1.03	–2.41	**	–1.55	–3.41	***
Type of model (Baseline is binary logit)						
MNL	–0.22	–1.19		–0.25	–1.02	
MXL	–0.46	–0.79		–0.80	–0.93	
Nested Logit	–0.08	–0.24		0.55	1.27	
MNP	–0.79	–2.19	**	–1.02	–2.18	**
Others	0.81	3.11	***	1.33	2.92	***
Age (Baseline is 65 year-old or more)						
Less than 65 year-old	–0.20	–0.64		–0.28	–0.44	
No data available	–0.44	–1.50		–0.57	–0.98	
Type of data (Baseline is SP)						
RP	0.04	0.23		–0.45	–1.94	*
RP+SP	–0.39	–1.43		–0.57	–1.81	*
Type of travel (Baseline is business)						
Home-to-workplace	0.17	0.40		0.02	0.02	
Home-to-school	–1.04	–2.31	**	–1.37	–1.59	
Home-to-workplace and -school	–0.09	–0.20		–0.16	–0.19	
Private	–0.62	–1.21		–0.19	–0.20	
Leisure	–0.11	–0.17		0.63	0.61	
Others	–0.15	–0.28		0.11	0.11	
Weekday/weekend day (Baseline is weekday)						
Weekend day	–0.06	–0.12		–1.15	–1.94	*
No data available	0.47	1.80	*	0.05	0.16	

Table 3 – Estimation results with VTTS estimates of urban travels (continued)

Attribute of travel (Baseline is all travel time)						
Access/egress time	0.44	2.31	**	1.07	4.91	***
Wait time at origin station	0.59	2.70	***	0.95	3.49	***
Transfer time at station	0.55	2.35	**	1.24	4.31	***
Headway	–0.58	–2.33	**	–0.08	–0.39	
Parking time	0.40	–1.00		0.36	0.77	
In-vehicle time	–0.02	–0.10		0.15	0.77	
Walk time	0.28	0.87		1.78	1.78	*
Others	–0.30	–0.63		–0.05	–0.07	
Research purpose (Baseline is VTTS estimation)						
Policy evaluation	–0.45	–2.20	**	0.41	1.74	*
Behavioral analysis	–0.04	–0.15		0.99	3.04	***
Mode-specific dummy variable						
Rail	–1.23	–4.65	***	–1.76	–5.86	***
Auto	0.61	2.70	***	1.05	3.42	***
Bus	–0.72	–3.08	***	–1.22	–4.00	***
Walk	0.42	–1.74	*	–0.60	–2.36	**
Park & Ride	0.73	2.61	***	0.27	0.72	
Constant	4.55	7.58	***	4.03	4.26	***
R^2		0.61			0.67	
Number of observations		183			183	

Table 4 – Estimation results with VTTS estimates of inter-urban travels

	OLS regression			WLS regression		
Variables	Coefficients	t-statistics		Coefficients	t-statistics	
Choice context (Baseline is modal choice)						
Route choice	–0.79	–1.91	*	–0.71	–0.70	
Destination choice	0.97	3.22	***	1.30	3.71	***
Airport choice	–0.30	–1.08		–0.44	–0.79	
Type of model (Baseline is binary logit)						
MNL	2.25	5.60	***	2.77	4.61	***
MXL	1.46	3.14	***	1.24	1.45	
Nested Logit	–0.45	–1.65	*	–0.52	–1.30	
MNP	1.38	2.36	**	1.04	0.78	
Others	–1.45	–2.92	***	–0.93	–1.16	
Age (Baseline is 65 year-old or more)						
No data available	0.13	0.16		0.32	0.19	
Type of data (Baseline is SP)						
RP	0.03	0.05		0.86	0.65	
Purpose of travel (Baseline is business)						
Private	0.81	1.62		0.85	1.08	
Leisure	–0.38	–0.97		–0.64	–0.88	
Others	0.49	1.08		0.68	0.87	
Weekday/weekend day (Baseline is weekday)						
Weekend day	–0.20	–0.44		–0.42	–0.53	
No data available	–0.94	–1.81	*	–1.17	–1.43	
Attribute of travel (Baseline is total travel time)						
Access/egress time	0.94	2.33	**	1.60	2.43	**
In-vehicle time	2.34	4.48	***	1.87	1.97	*

Table 4 – Estimation results with VTTS estimates of inter-urban travels (continued)

Research purpose (Baseline is VTTS estimation)						
Policy evaluation	0.66	1.82	*	0.97	2.07	**
Behavioral analysis	1.01	2.63	***	1.49	2.80	***
Mode-specific dummy variable						
Rail	2.68	6.70	***	2.53	3.40	***
Auto	–1.49	–2.25	**	–1.57	–1.34	
Bus	0.05	0.10		–0.09	–0.09	
Air transport	0.21	0.53		0.79	2.32	**
Ferry	–0.37	–0.51		1.14	0.94	
Constant	1.69	1.99	*	0.18	0.14	
R^2	0.89			0.95		
Number of observations	62			62		

5. DISCUSSIONS

5.1. Variation of VTTS by travel purpose

The results of the regressions with all VTTS estimates show that the VTTS of business travel is higher than the VTTSs of home-to-school travel, private travel, and leisure travel. The estimated VTTSs of business travel, home-to-school travel, private travel, and leisure travel are 34.1, 10.4, 17.6, and 17.1 yen per minute respectively when it is assumed that the all-data-OLS-regression-based VTTS of total travel time on a weekday is estimated for the purpose of VTTS estimation with a binary-logit-based modal-choice model using RP data for auto-use urban travels of less than 65 year-old travelers. This means that the ratios of VTTSs of home-to-school travel, private travel, and leisure travel to VTTS of business travel are 0.30, 0.52, and 0.50, respectively. This is similar to the results of meta-analysis in other countries (For example, in Great Brain Wardman, 2001). In other countries, the VTTS of the non-business travel is often considered to be about 50 % of the VTTS of business travel (Small and Verhoef, 2007). The reasons for higher VTTS of business travel are considered in the following two ways. The first case is that the employers are traveling for business purpose. As the employers have higher wage rate than others in general, their VTTS becomes also higher. The second case is that the employees are traveling for business purpose. As the employed business persons follow the resource allocation shown by employers, their VTTS reflects the VTTS of employers.

Interestingly, the VTTS of home-to-workplace travel and the VTTS of home-to-workplace and -school are not significantly different from the VTTS of business travel in the regressions with all VTTS estimates and the regression with VTTS estimates of urban travels. For example, the estimated VTTSs of business travel, home-to-workplace travel, and home-to-workplace and -school travel are 34.1, 31.8, and 25.8 yen per minute respectively when it is assumed that the all-data-OLS-regression-based VTTS of total travel time on a weekday is estimated for the purpose of VTTS estimation with a binary-logit-based modal-choice model using RP data for auto-use urban travels of less than 65 year-old travelers. This means that the ratios of VTTSs of home-to-workplace travel and home-to-workplace and -school travel to VTTS of business travel are 0.93 and 0.76, respectively. Note that the VTTS of “home-to-workplace and -school” is considered to be nearly equal to the VTTS of home-to-workplace because the number of commuters is much more than that of the student travelers in general. Why is the VTTS of home-to-workplace travel as high as the VTTS of business travel in Japan? There are two possible reasons for high VTTS of home-to-work travel. The first reason is the serious traffic congestion during morning peak hours, particularly in urban rail service in large cities. For instance, in Tokyo, the serious in-vehicle congestion of rail service during morning peak hours forces the commuters to keep standing in the clammed space for long travel time.

This should increase the value of travel time as a commodity for home-to-work travels. The second reason is the unique work time system in Japan. The most companies in Japan apply the fixed work time system, in which the employees must start their work at the fixed time, for instance 8:30 am. This means that many commuters face the tight time constraint, under which they cannot adjust the leisure time between morning and other time of a day. If it is assumed that the marginal utility is decreasing by following the conventional microeconomic theory, the marginal utility with respect to leisure time is larger with the morning-time-constraint than without the morning-time-constraint. This leads to higher value of travel time as a resource for home-to-work travels.

5.2. Variation of VTTS over travel time

Although the VTTS of inter-urban travel is not significantly higher than the VTTS of urban travel, the VTTSs of inter-urban rail and air transportation are higher than the VTTS of automobile. As discussed earlier, one of the possible reasons is because the inter-urban travelers who may use the rail or air transportation are business persons who have high willingness to pay for saving travel time. The other possible reason is because the total travel time in inter-urban rail-use and air-transportation-use travels is longer than that in inter-urban automobile-use travel. In general, longer travel time cause higher VTTS. This is because the longer travel time reduces the available time for leisure. If it is assumed that the marginal utility with respect to leisure time is decreasing as leisure time increases, the reduction of leisure time leads to higher marginal utility with respect to leisure time. However, it should be noted that the 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 due to the long travel time, the travelers change their schedule from one-day trip to 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 (2009) in the context of inter-urban transportation in Japan.

5.3. Variation of VTTS by travel mode

The VTTSs of access/egress travel, wait time at origin station, and transfer time at station are higher than the VTTS of in-vehicle travel time. This is mainly because the value of travel time as a commodity is greater in in-vehicle travel time than that in access/egress travel, wait time, and transfer time. Note that the above consideration is based on the assumption of negative marginal utility with respect to travel time.

The VTTS of automobile is higher than the baseline value of urban travel while the VTTS of automobile is lower than the baseline value of inter-urban travel. In the context of urban travel, the higher VTTS of automobile is probably because automobile users earn higher income than non-automobile users. In the context of inter-urban travel, the lower VTTS of automobile is probably because the inter-urban air-transportation-use and/or rail-use travelers are business persons who have higher willingness to pay for saving travel time.

5.4. VTTS of in-vehicle travel versus VTTS of out-of-vehicle travel

The WLS-based meta-analysis results of urban travel show that the VTTSs of out-of-vehicle travel time including access/egress time, wait time at origin station, and transfer time at station are higher than the VTTS of in-vehicle travel time (or the baseline value) by about 100 %. This supports the convention to weight walk and wait time at twice the rate of in-vehicle time (Wardman, 2004).

6. CONCLUSIONS

This paper analyzed the characteristics of VTTS of passenger transportation in Japan. The meta-analysis including the regression models are used for empirical analysis. The data used for the meta-analysis is the VTTS estimations in the past papers published in the Japanese journals. This is the first trial of meta-analysis of VTTS in Japan. First, there are some results in our meta-analysis that have the similarities to the results of the meta-analysis in other countries. For example, the VTTS estimated with RP survey data is higher than that estimated with SP survey data. This is the same result as the British evidence (Wardman, 2001). On the contrary, there are also the results that have the difference from the results of the past research. For example, our results show that the VTTS home-to-work travel is indifferent from the VTTS of business travel. This is the different result from the British evidence in which the business travels have higher VTTS than the non-business travels (Wardman, 2001). This may reflect the unique conditions of work system in Japan. Finally, the paper also found new evidences from the unique challenges in the meta-analysis including the type of model, weekday/weekend day, and research purpose. For example, the results of meta-analysis in urban travel show that the VTTS in the paper which is concerned with behavioral analysis is higher than the VTTS in the paper which is concerned with VTTS estimation. This may reflect the political pressure on researchers for suppressing the VTTS in the context of Japan.

Transportation planners often must make judgements concerning relative values, or even of updating models with limited available evidence (Wardman, 2001). The VTTS also depends on the local context and environment. Thus, it is highly expected that the models and evidence reported in this paper could be of considerable use in or contribute to any type of transportation planning including the cost-benefit analysis for evaluating the transportation investment in Japan.

The further research issues are summarized as follows. First, the data used in our analysis is only refereed academic papers. Although the quality of data is guaranteed, the number of data is quite limited. Since there are other studies that were not published in academic journals but published as a technical report, richer analysis may be possible by incorporating these studies in the meta-analysis. Second, some important attributes or factors are not included in our meta-analysis although they are included in the past similar research. For example, the trip distance is not included in our analysis. This is because the data regarding trip distance is not available from our database. Finally, the value of freight travel time saving (VFTTS) should be explored further more. However, as the past studies of VFTTS estimates are quite limited in Japan, it may be difficult to try the meta-analysis at this moment. We expect the accumulation of the related researches.

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REFERENCES

Armstrong, P., Garrido, R., de Dios Ortuzar, J., 2001. Confidence intervals to bound the value of time. Transportation Research 37E, 143–161.

Axhausen, K. W., Hess, S., König, A., Abay, G., Bates, J. J., Bierlaire, M., 2008. Income and distance elasticities of values of travel time savings: New Swiss results. Transport Policy 15(3), 173–185.

Baaijens, S. R., Nijkamp, P., Van Monfort, K., 1997. Explanatory meta-analysis for the comparison and transfer of regional tourist income multipliers. Regional Studies 32, 839–849.

Baaijens, S., Nijkamp, P., 2000. Meta-analytic methods for comparative and exploratory policy research. Journal of Policy Modelling 22(7), 821–858.

Bate, J. J., 1987. Measuring travel time values with a discrete choice model: A note. Economic Journal 97, 493–498.

Ben-Akiva, M., Lerman, S., 1985. Discrete choice analysis: Theory and application to travel demand, MIT Press.

Blayac, T., Causse, A., 2001. Value of travel time: A theoretical legitimization of some nonlinear representative utility in discrete choice models. Transportation Research 35B, 391–400.

Becker, G. A., 1965. Theory of the allocation of time. Economic Journal 75, 493–517.

Bickel, P., Friedrich, R., Burgess, A., Fagiani, P., Hunt, A., De Jong, G., Laird, J, Lieb, C., Lindberg, G., Mackie, P., Navrud, S., Odgaard, T., Ricci, A., Shires, J., and Tavasszy, L., 2006. HEATCO Deliverable 5: Proposal for Harmonised Guidelines.

Colloings, J. J., 1974. The valuation of leisure time, a note. Regional and Urban Economics 4, 65–67.

De Serpa, A. C., 1971. A theory of the economics of time. Economic Journal 81, 828–846.

Dillen, J.L., Algers, S., 1999. Further research on the national Swedish value of time study, in: Meersman, H., Van de Voorde, E., Winkelmans, W. (Eds.), Proceedings of the Eighth World Conference on Transport Research Transport Modelling/Assessment, Vol. 3. Pergamon Press, Amsterdam, 135–148.

Espey, M., 1998. Gasonline demand revisited: an international meta-analysis of elasticities. Energy Economics 20, 273–295.

Evans, A., 1972. On the theory of the valuation and allocation of time. Scottish Journal of Political Economy 19, 1–17.

Green, W. H., 2008. Econometric Analysis, sixth edition, Pearson Prentice Hall.

Gunn, H.F., Rohr, C. 1996. The 1985–1996 Dutch Value of Time Studies. Paper presented at PTRC International Conference on the Value of Time.

Gunn, H.F., Tuinenga, J.G., Cheung, Y.H.F., Kleijn, H.J., 1999. Value of Dutch Travel Time Savings in 1997, in: Meersman, H., Van de Voorde, E., Winkelmans, W. (Eds.), Proceedings of the Eighth World Conference on Transport Research Transport Modelling/Assessment, Vol. 3. Pergamon, Amsterdam, 513–526.

Hague Consulting Group, 1990. The Netherlands Value of Time Study: Final Report. Report to Dienst Verkeerskunde, Rijkswaterstaat, The Hague.

Hague Consulting Group and Accent Marketing and Research, 1999. The Value of Travel Time on UK Road – 1994. Prepared for the Department of Transport.

Hensher, D.A., 2001. Measurement of the valuation of travel time savings. Journal of Transport Economics and Policy 35 (1), 71–98.

Hunterm, J. E., Schmidt, F. L., 2004. Methods of Meta-Analysis: Correcting Error and Bias in Research Findings, Sage Publishers.

Jara-Diaz, S. R., 2003. On the goods-activities technical relations in the time allocation theory. Transportation 30, 245–260.

Kato, H., 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. Presented at Transportation Research Board 88th Annual Meeting, Washington D. C., January 2009

Kremers, H., Nijkamp, P., Rietveld, P., 2002. A meta-analysis of price elasticities of transport demand in a general equilibrium framework. Economic Modeling 19, 463–485.

Kulinskaya, E., Morgenthaler, S., Staudte, R. G., 2008. Meta Analysis: A Guide to Calibrating and Combining Statistical Evidence, John Wiley & Sons.

Mackie, P.J., Wardman, M., Fowkes, A.S., Whelan, G., Nellthorp, J., Bates, J., 2003. Values of Travel Time Savings in the UK. Report prepared for Department of Transport. Institute for Transport Studies, University of Leeds.

McFadden, D., 2001. Economic choices. American Economic Review 91(3), 351–378.

MVA Consultancy, ITS University of Leeds and TSU University of Oxford, 1987. Value of Travel Time Savings, Policy Journals, Newbury, Berks.

Oort, C. J., 1969. The evaluation of traveling time. Journal of Transport Economics and Policy 1, 279–286.

Pursula, M., Kurri, J., 1996. Value of time research in Finland. Paper presented at PTRC International Conference on the Value of Time.

Ramjerdi, F., Rand, L., Sælensminde, K., 1997. The Norwegian Value of Time Study: Some Preliminary Results. Institute of Transport Economics, Oslo, Norway.

Rosenthal, R., Di Matteo, M. R., 2001. Meta-analysis: recent developments in quantitative methods for literature reviews. Annual Review of Psychology 52, 59–82.

Small, K., Verhoef, E. T., 2007. The Economics of Urban Transportation, 2nd Edition, Routledge.

Small, K.A., Noland, R., Chu, X., Lewis, D., 1999. Valuation of Travel-Time Savings and Predictability in Congested Conditions for Highway User-Cost Estimation. National Cooperative Highway Research Program. Report 431, Transportation Research Board, Washington DC.

Train, K., McFadden, D., 1978. The goods/leisure trade-off and disaggregate work trip mode choice models. Transportation Research 12, 349–353.

Truong, T. P., Hensher, D. A., 1985. Measurement of travel time values and opportunity cost from a discrete-choice model. Economic Journal 95, 438–451.

Truong, T. P., Hensher, D. A., 1987. Measuring travel time with a discrete choice model: A reply. Economic Journal 97, 499–501.

Wardman, M., 1998. The value of travel time — A review of British evidence. Journal of Transport Economics and Policy 32, 285–316.

Wardman, M., 2001. A review of British evidence on time and service quality valuation. Transportation Research 37E, 107–128.

Wardman, M., 2004. Public transport values of time. Transport Policy 11, 363–377.

Zamparini, L., Reggiani, A., 2007a. Meta-Analysis and the value of travel time savings: A transatlantic perspective in passenger transport. Networks and Spatial Economics 7(4), 377–396.

Zamparini, L., Reggiani, A., 2007b. Freight transport and the value of travel time savings: A meta-analysis of empirical studies. Transport Reviews 27(5), 621–636.