

VALUES OF TRAVEL TIME SAVINGS: CURRENT JAPANESE RESULTS

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Introduction

- The benefit of transportation investment mainly stems from the saving travel time.
- The value of travel time saving (VTTS) is widely used to evaluate the benefit of travel time saving.
- However, the empirical research on VTTS has not been sufficient in Japan.

Background of VTTS research in Japan

- The latest VTTS guideline was made in 2010.
 - It was examined by a research committee commissioned by the Government.
- However, the committee pointed out the lack of empirical analysis on non-business VTTS reflecting the context of Japan.
- Then, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in Japan has started the research on VTTS.

VTTTS research project

- Three-year research project in 2009-2012 funded by Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan.
- Project team was headed by Dr. Hironori Kato (The University of Tokyo).
- The goals of the research project were
 - Empirical analysis on VTTTS in Japan
 - Collection of information on VTTTS guidelines in other countries
 - Discussions on VTTTS in the context of Japan
- Final report was submitted to the MLIT in September 2012.

Project evaluation of road project in Japan

- Conventional approach of CBA
 - Project period = 50 yrs
 - Social discount rate = 4%
 - Cost benefit ratio, net present value, and economic rate of return are used for evaluation
- Benefit covers the three types of benefits
 - Saving travel time
 - Saving travel cost
 - Reduction of traffic accident

Guideline of VTTS for Road Project Evaluation in Japan

- Wage-rate-plus approach
- Opportunity cost is estimated from the statistical data on the average wage rate and the fringe benefit
 - VTTS of business trip vs. VTTS of non-business trip
 - VTTS of a driver vs. VTTS of passengers

Guideline of VTTS for Road Project Evaluation in Japan

- Business travel
 - Opportunity cost = average wage rate + fringe benefit
 - Average wage rate is estimated incorporating the difference of wage rates between permanent workers and non-permanent workers
 - “Fringe benefit” includes the additional allowances for employees
- Non-business travel
 - Opportunity cost = average wage rate – tax
 - Tax includes only consumption tax (5%)
 - Wage rate is assumed to be zero for under-15-year-old individuals

VTTs for Road Project Evaluation in Japan

Individual's VTTs by type of travel (MLIT, 2008)

Type of travel	VTTs (JPY/Minute)
Business travel	43.95
Non-business travel (driver)	28.87
Non-business travel (passenger)	24.94

Note: 1 CHF = approximately 80 JPY (as of 2008)

VTTs for Road Project Evaluation in Japan (Continued)

VTTs by type of vehicle (MLIT, 2008)

Type of vehicle	VTTs (JPY/Minute per Vehicle)
Passenger Car	40.10
Bus	374.27
Passenger Cars + Bus + Taxi	45.78
Light Freight Vehicle	47.91
Ordinary Freight Vehicle	64.18

Note 1: Weighted average of VTTs including business and non-business travels

Note 2: Opportunity cost of vehicle is added to that of individuals

Note 3: Average number of passengers per vehicle is considered

Empirical analyses of VTTs in Japan

VTTs estimation with large-scale RP data of road users in Japan

Goal of the study and data

- This study empirically estimates the VTTs in a choice context where the expressway service is chosen or not in Japan.
- The empirical analysis will use the 2005 Road Traffic Census Data.
 - This data includes two types of origin-destination (O-D) surveys: an O-D survey based on intercept interviews with drivers crossing given survey points and an O-D survey based on household interviews with vehicle owners.
 - This survey covered the entire nation.

Level-of-service (LOS) data

- LOS data including the travel time and travel cost is prepared for the empirical analysis.
 - Zoning system: 6 795 zones.
 - Road network: prefectural roads, national roads, and expressways on the basis of the Digital Road Map Database in Japan.
 - Link-based travel time: estimation using the BPR function
 - Link-based travel cost: calculation using the fare tables provided by expressway operators. No fuel cost is included.

Sample dataset for empirical analysis

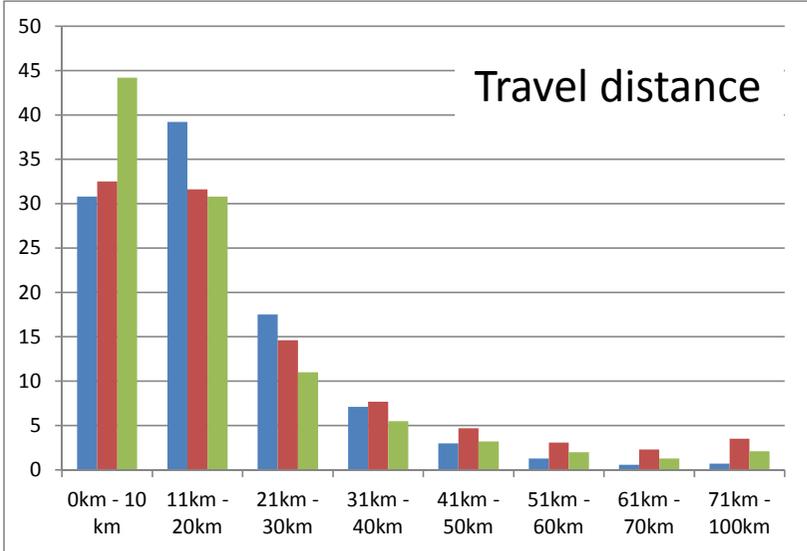
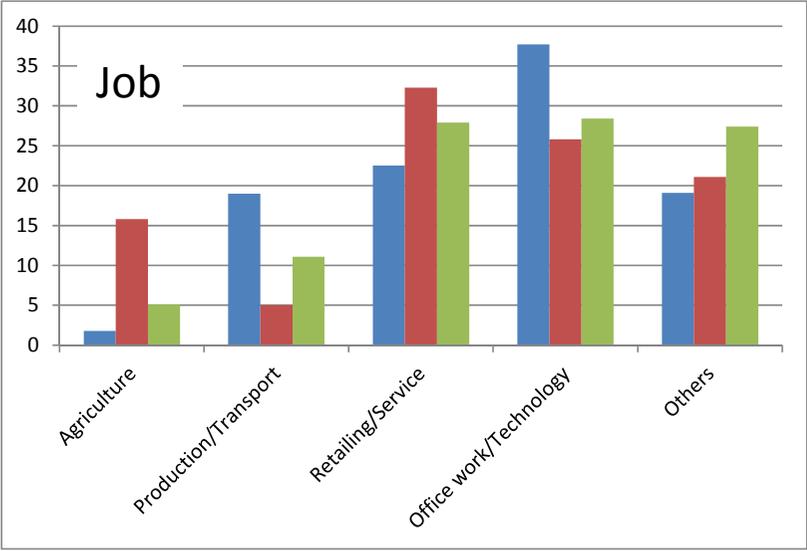
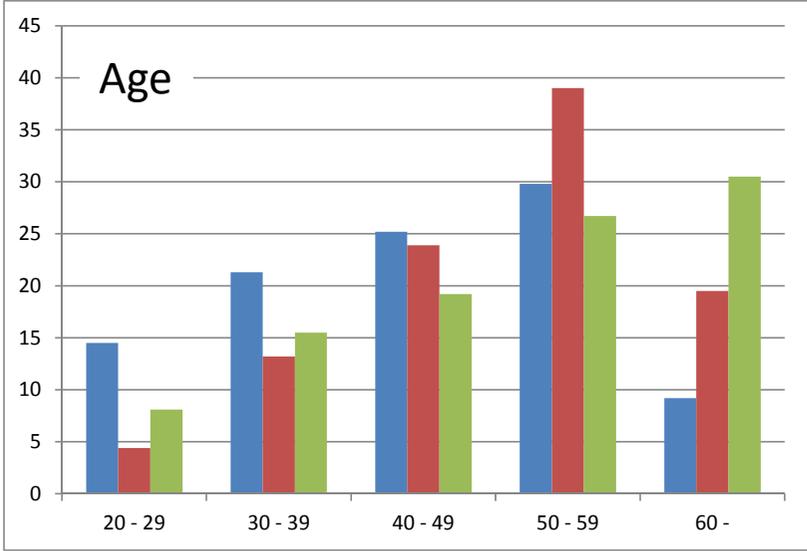
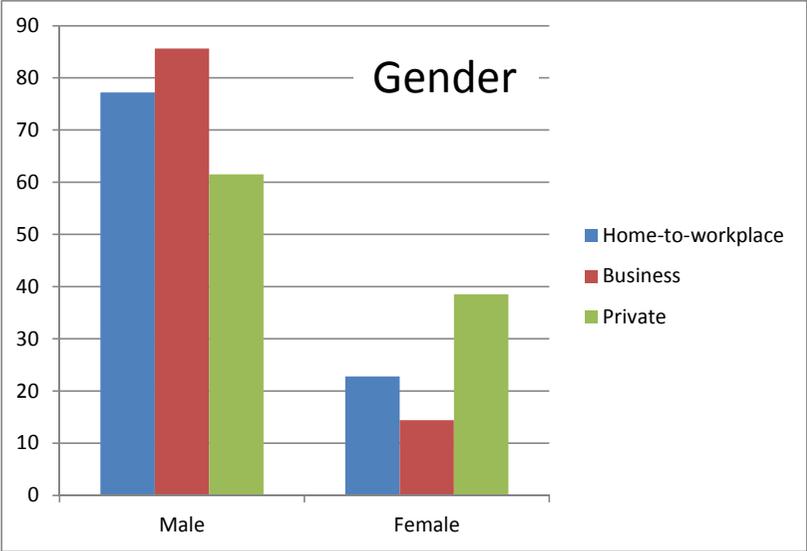
The sample dataset is constructed by excluding:

- home-to-school travel and pick-up travel
- workplace/school/others-to-home travel
- intra-zone trips and the trips including ferry-use
- the trips to and from the Shikoku Island
- the trips that were made by the individuals whose route choice set have only the no-expressway route

Size of sample datasets by travel purpose

Travel purpose	Sample size
Home-to-workplace	82,068 (Exp. : 2,769, No-exp. : 79,299)
Private	51,621 (Exp. : 2,082, No-exp. : 49,539)
Business	12,328 (Exp. : 1,127, No-exp. : 11,201)

Descriptive statistics



Estimation of VTTS with BL (Kato et al. 2011)

Binary logit: expressway route vs. no-expressway route

Utility functions

$$\text{Expressway route } V_{h,n} = \beta_{TT} \cdot T_{h,n} + \beta_{TC} \cdot C_{h,n}$$

$$\text{No-expressway route } V_{g,n} = \beta_{TT} \cdot T_{g,n}$$

$V_{i,n}$: Indirect utility function of route i for individual n

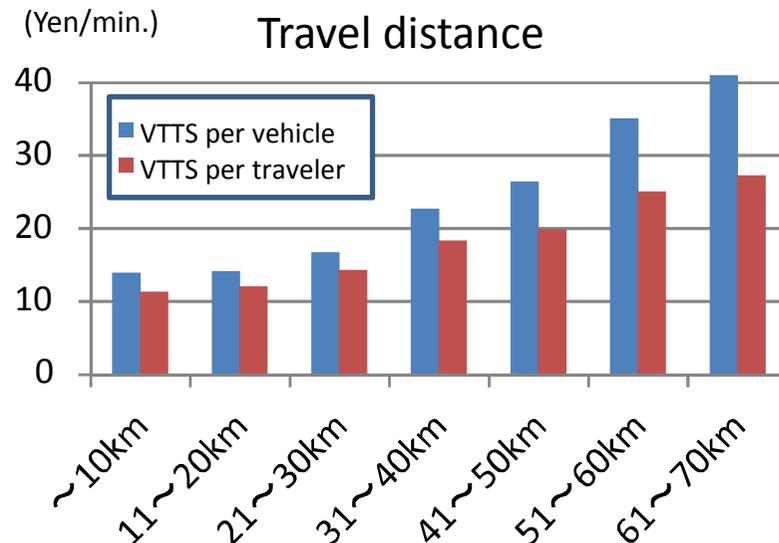
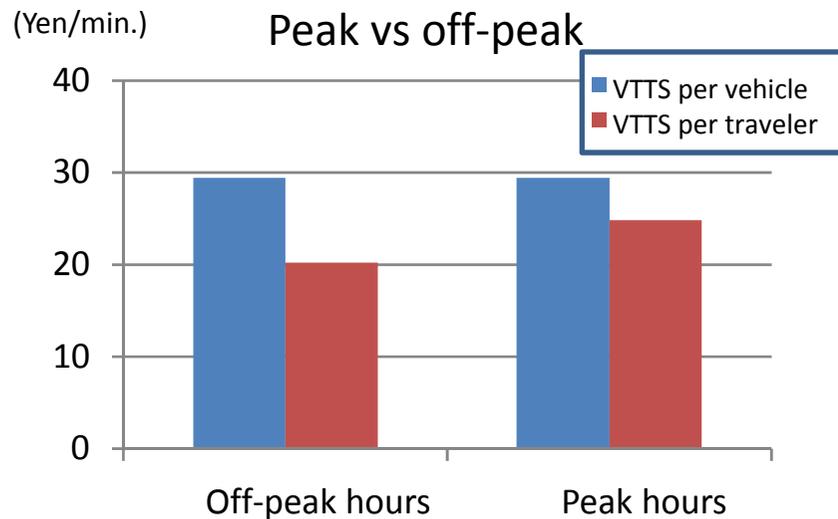
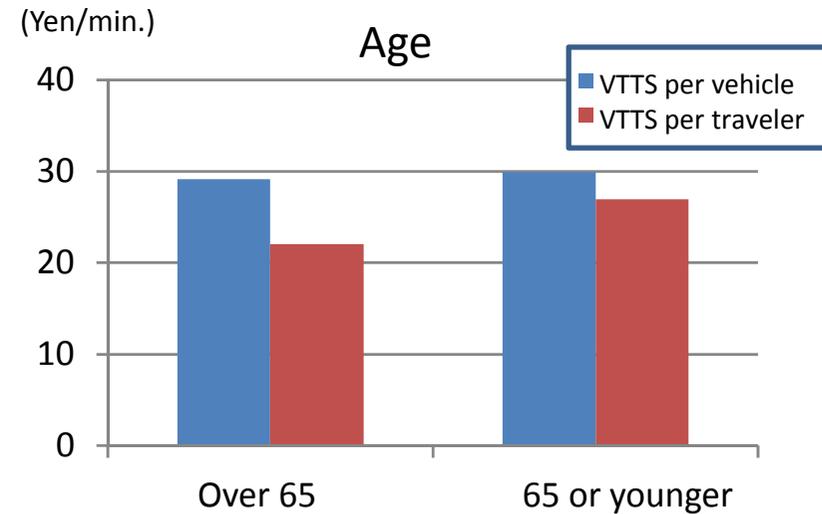
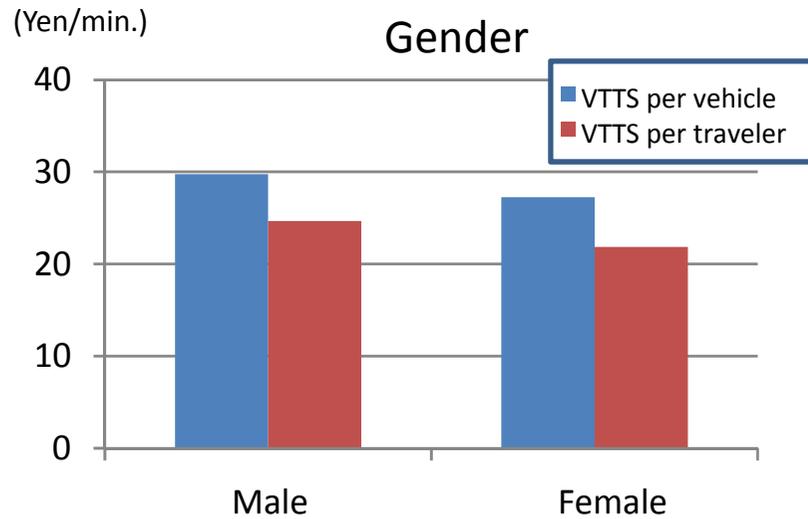
β_{TT} : Coefficient of travel time T

β_{TC} : Coefficient of travel cost C

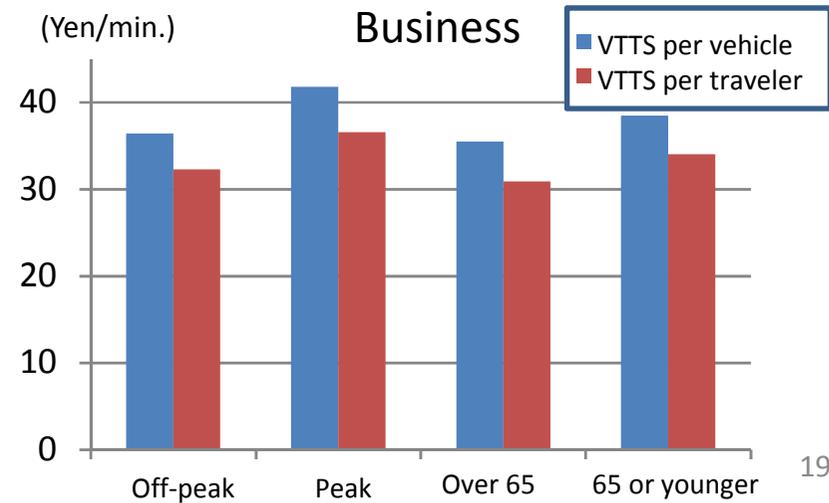
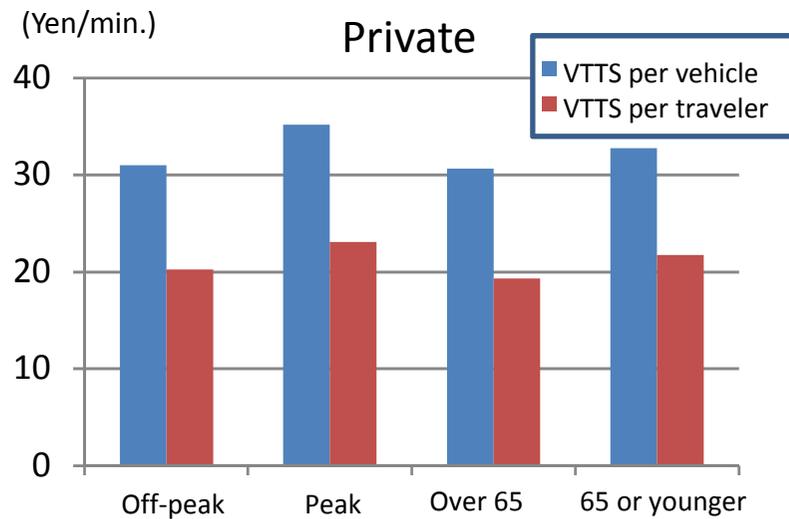
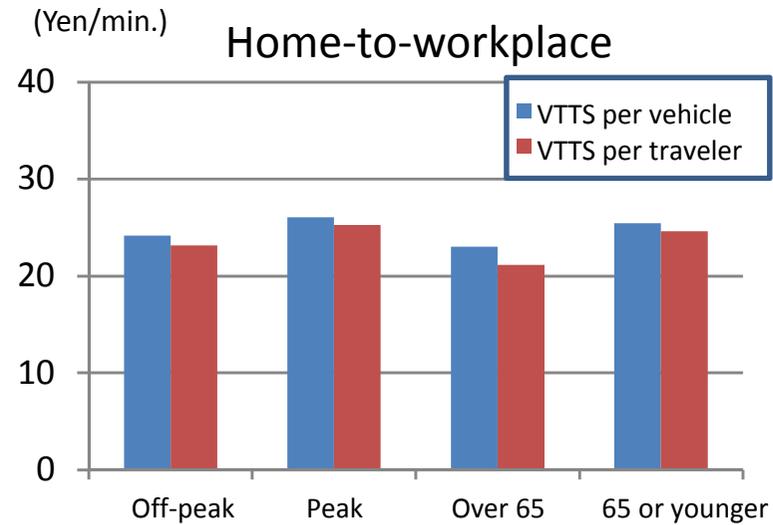
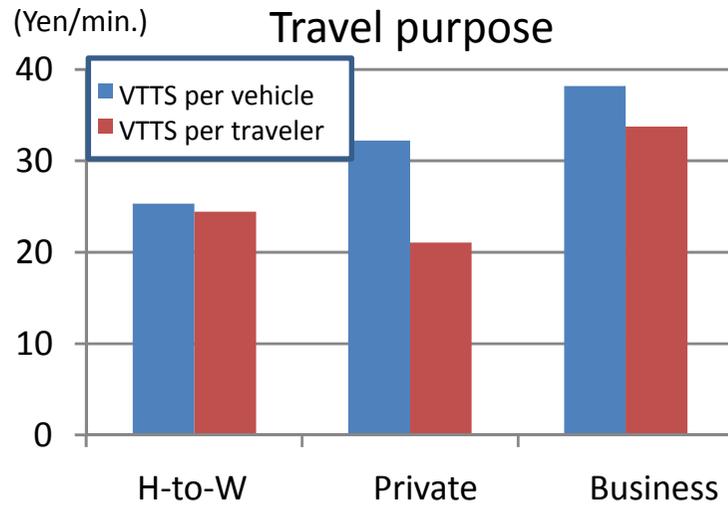
$T_{i,n}$: Travel time of route i for individual n (Min.)

$C_{h,n}$: Travel cost of Expressway route (Yen)

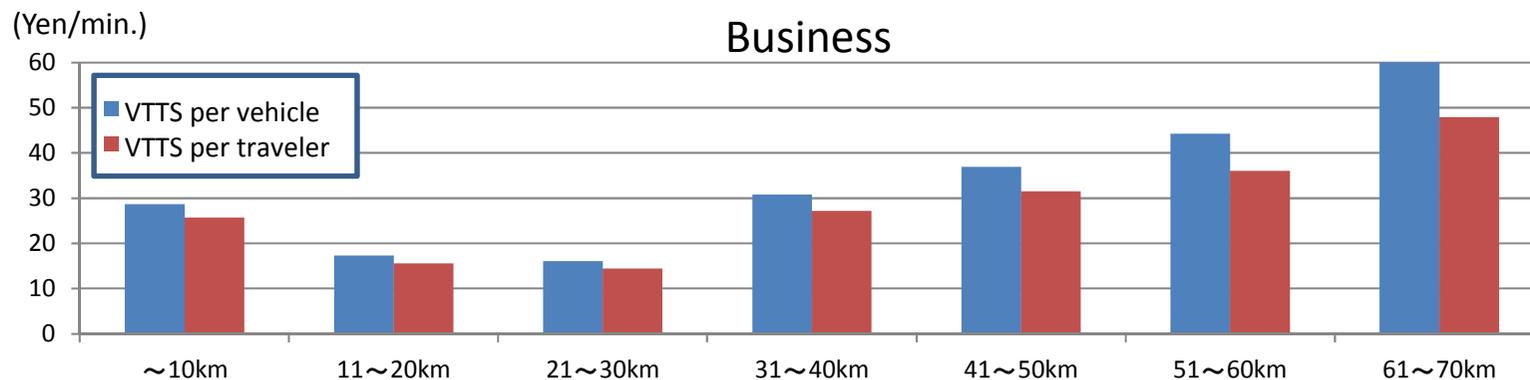
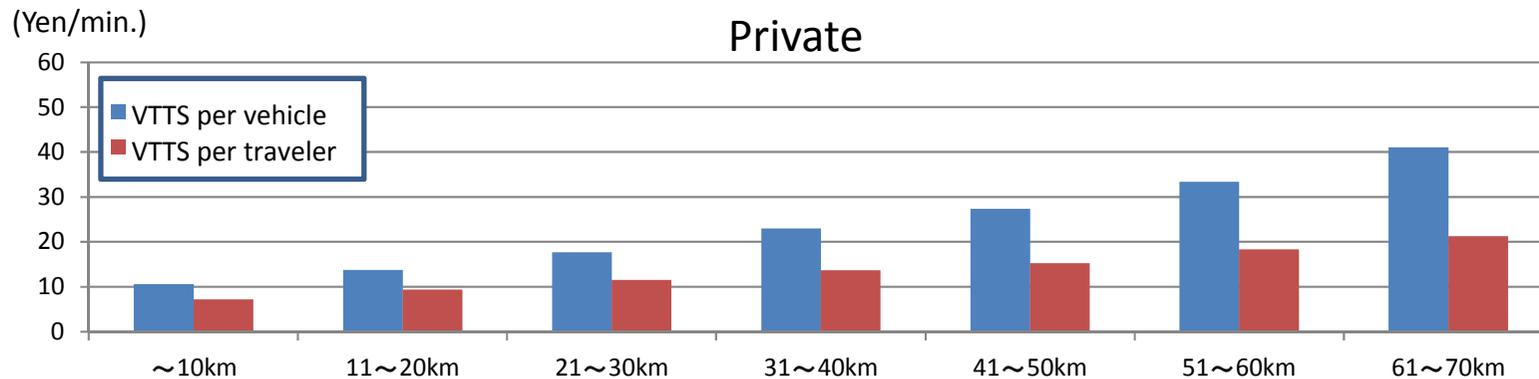
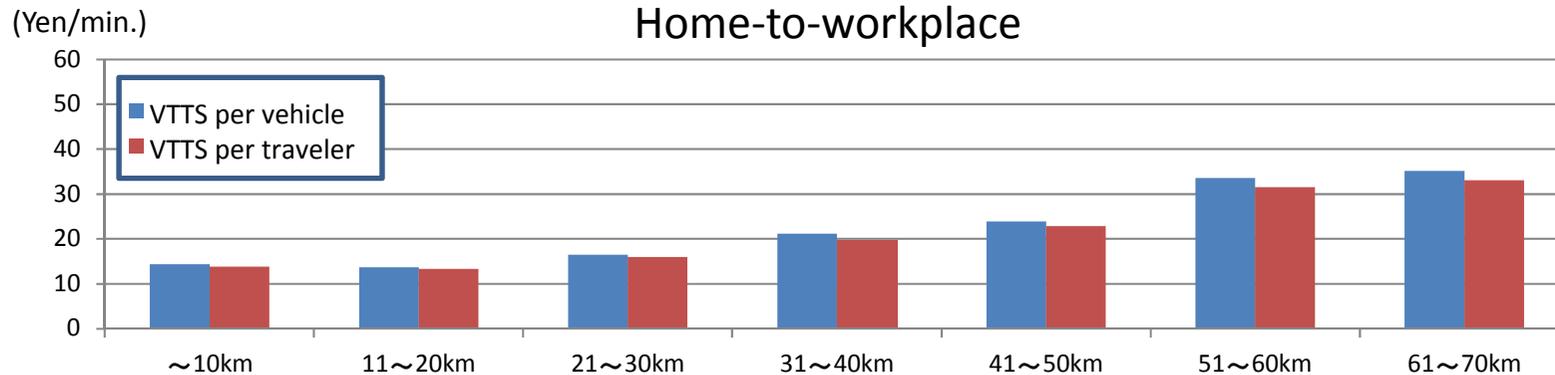
Estimated VTTs by traveler's attribute



Estimated VTTs by travel purpose



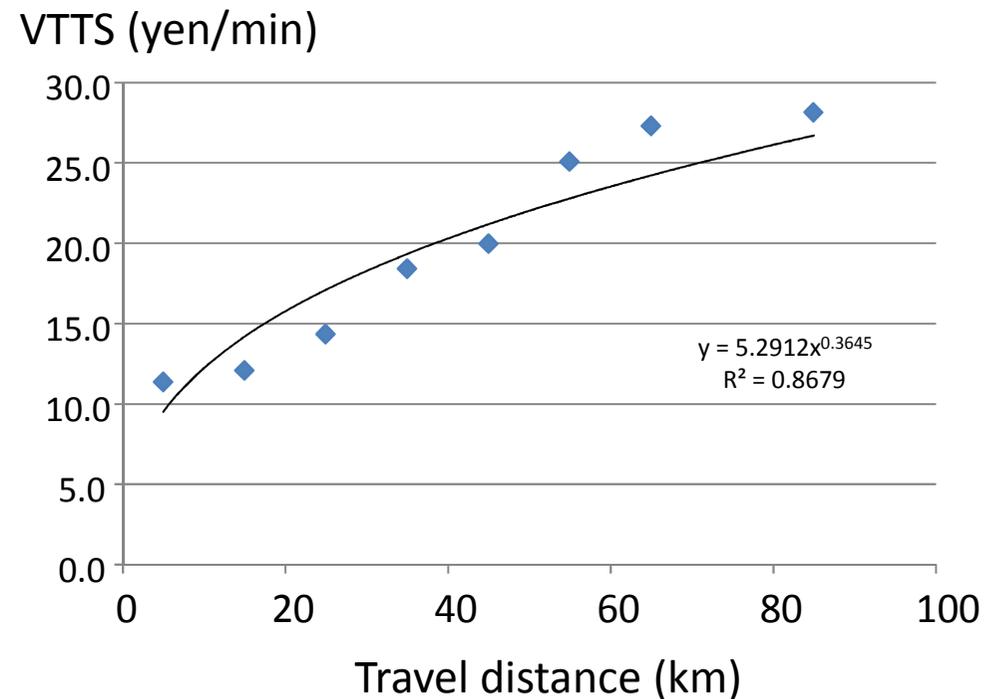
Estimated VTTs by travel distance



Distance elasticities of VTTS

- The distance elasticities of VTTS are estimated with the results of RP-based VTTS estimation with large-data set in Japan.
- Results are
 - 0.37 for all purposes
 - 0.39 for H-to-W
 - 0.77 for business*
 - 0.41 for private
- UK's results (Abrantes and Wardman, 2011)
 - 0.08 for leisure
 - 0.45 for business

Regression analysis on travel distance vs. VTTS
(All travel purposes)



Note*: Estimated VTTS of less than 10km is eliminated for estimation

Additional analysis:

Estimation of VTTS with Mixed BL

Mixed BL: expressway route vs. no-expressway route

Utility Functions

Expressway route $V_{h,n} = \beta_{TT}(\varepsilon_{TT,n}) \cdot T_{h,n} + \beta_{TC}(\varepsilon_{TC,n}) \cdot C_{h,n} + \beta_C$

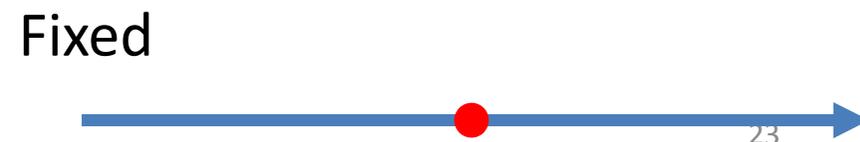
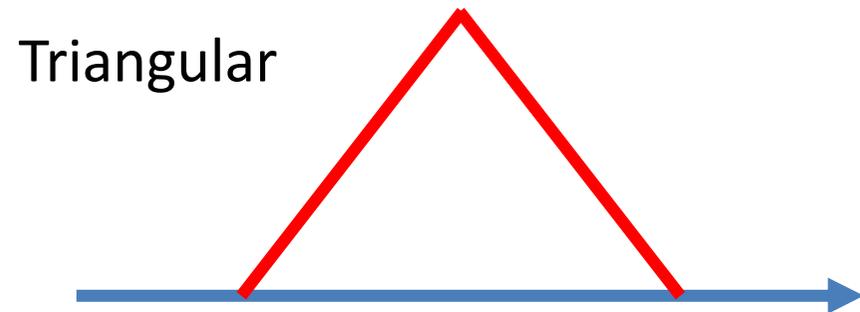
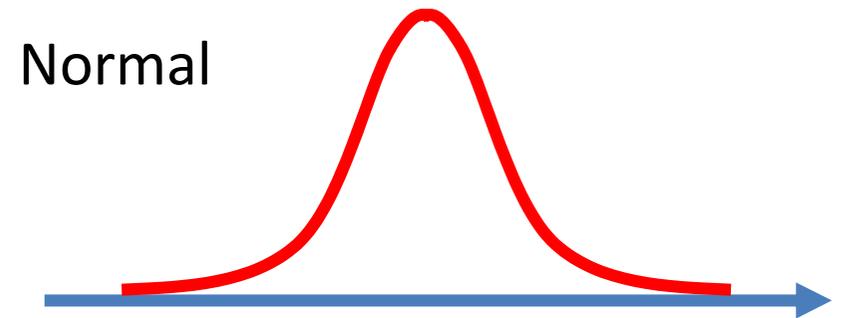
No-expressway route $V_{g,n} = \beta_{TT}(\varepsilon_{TT,n}) \cdot T_{g,n}$

Estimation: Using R for estimating coefficients.

- 125 Halton Draws (Bhat, 2001; Train, 1999)
- 50,000 draws of time and cost parameters from their distributions and the ratio over the two values are computed (Cirillo and Axhausen, 2006).

Distribution functions

- Four types of probability functions for random coefficients of travel time and travel cost:
 - Normal distribution;
 - Triangular distribution;
 - Uniform distribution;
 - Fixed
- In total, 16 cases are estimated for each trip purpose



Estimation results (Business)

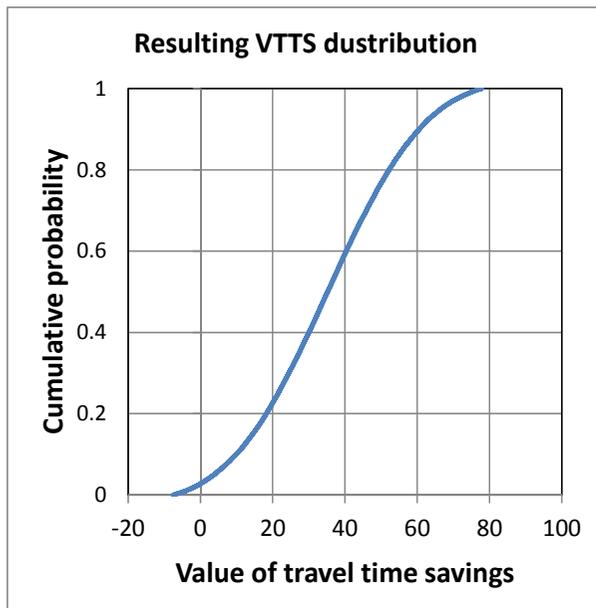
Distribution of Beta TT	Distribution of Beta TC	L(Beta)	Beta TT: share of below and including zero	Beta TC: share of below and including zero	VTTS: share of below and including zero	VTTS distribution		
						95%	Mean	Median
Normal	Normal	-3933	88.6	55.5	45.9	4.307	0.916	0.086
Normal	triangular	-4982	100	64	36	48.758	11.142	6.855
Normal	Uniform	-5772	28.7	61.3	54.7	0.487	-0.369	-0.034
Normal	Fixed	-2349	97.2	n.b.d.	2.8	63.735	35.212	34.101
Triangular	Normal	-3884	47.3	55.1	50.5	9.646	1.69	-0.211
Triangular	triangular	-3279	73.5	83.2	34.9	47.758	17.266	5.051
Triangular	Uniform	-6414	88.9	57.5	44.5	3.301	-5.94	0.136
Triangular	Fixed	-2351	100	n.b.d.	0	56.73	40.004	39.438
Uniform	Normal	-3919	57.5	57.3	49.2	12.288	1.747	-0.173
Uniform	triangular	-2626	100	84.6	15.4	79.88	51.646	15.162
Uniform	Uniform	-6713	63.5	56.8	48	6.224	16.282	-0.007
Uniform	Fixed	-2348	80.7	n.b.d.	19.3	86.319	36.051	34.018
Fixed	Normal	-3814	n.b.d.	54.9	45.1	16.612	27.118	1.8
Fixed	triangular	-3929	n.b.d.	77.5	22.5	19.817	3.265	3.776
Fixed	Uniform	-3026	n.b.d.	71.1	28.9	7.839	0.12	1.336
Fixed	Fixed	-2402	n.b.d.	n.b.d.	100	n.b.d.	-156.932	n.b.d.

Estimation results (All purposes)

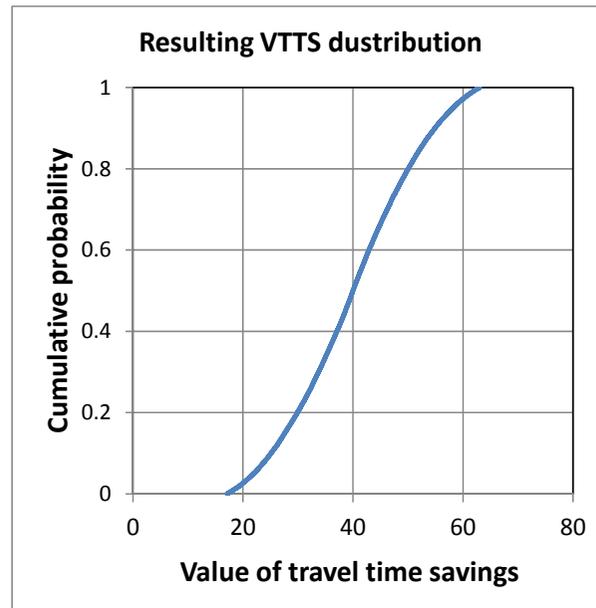
Trip purpose	Distribution of Beta TT	Distribution of Beta TC	L(Beta)	Beta TT: share of below and including zero	Beta TC: share of below and including zero	VTTS: share of below and including zero	VTTS distribution		
							95%	Mean	Median
Business	Uniform	Fixed	-2348	80.7	n.b.d.	19.3	86.319	36.051	34.018
	Normal	Fixed	-2349	97.2	n.b.d.	2.8	63.735	35.212	34.101
	Triangular	Fixed	-2351	100	n.b.d.	0	56.73	40.004	39.438
	Fixed	Fixed	-2402	n.b.d.	n.b.d.	n.b.d.	n.b.d.	-156.932	n.b.d.
Private	Uniform	Uniform	-5074.3	100	100	0	177.32	105.827	102.261
	Uniform	Fixed	-5122.2	79.4	n.b.d.	20.6	99.939	40.687	38.291
	Triangular	Fixed	-5140.4	100	n.b.d.	0	64.982	45.908	45.261
	Normal	fixed	-5127.2	96.6	n.b.d.	3.4	73.901	40.186	38.873
	Fixed	Fixed	-5280.5	n.b.d.	n.b.d.	n.b.d.	n.b.d.	-188.748	n.b.d.
Private + Home-to-workplace	Uniform	Fixed	-13820	82.2	n.b.d.	17.8	87.034	37.363	35.354
	Triangular	Fixed	-13853	100	n.b.d.	0	57.893	41.813	41.268
	Normal	Fixed	-13826	98.1	n.b.d.	1.9	65.424	36.894	35.783
	fixed	Fixed	-14081	n.b.d.	n.b.d.	n.b.d.	n.b.d.	-177.847	n.b.d.

VTTS distributions (Business)

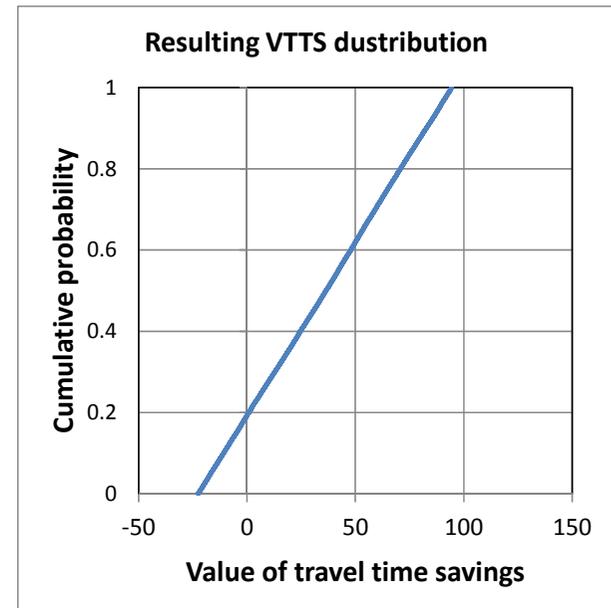
Normal-Fixed
(Business)



Triangular -Fixed
(Business)



Uniform- Fixed
(Business)



Meta-analysis of VTTs in Japan

Goals of the study

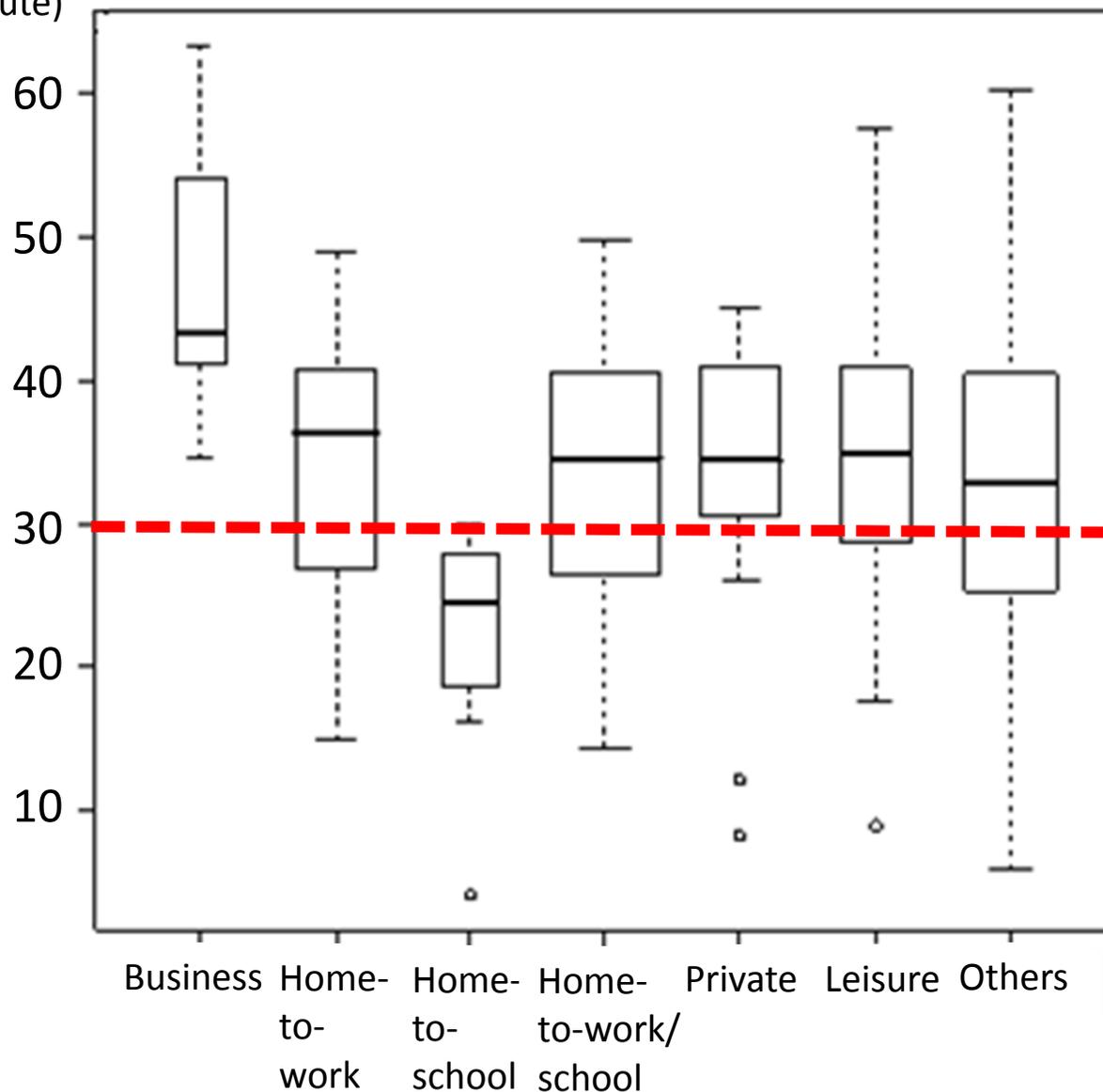
- Meta-analysis of VTTSs in the context of Japan.
 - This is the first trial of meta-analysis of VTTS particularly incorporating GDP in Japan.
 - No meta-analysis on the VTTS has been reported in Japan although a number of empirical studies analyzed the travel behavior and estimated the VTTSs
 - The studies that estimate the VTTS of Japanese traveler mainly with the discrete choice models are used for our meta-analysis.

Dataset for meta-analysis

- Academic papers that were all peer-reviewed in the journals published in Japan.
 - 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)
- 261 VTTSs estimated in 68 peer-reviewed papers on travel behavior in Japan from 1979 to 2003

Descriptive statistics

(Yen/minute)



Average wage
rate in Japan
(2000)

Meta regressions analysis (Kato et al, 2010)

- Meta regressions analysis (Wardman, 1998)

$$\ln(VTTS_t) = \mu + \alpha \ln GDP_t + \sum_{j=1}^p \beta_j Z_{tj} + u_t$$

- μ denotes a constant; Z denotes the explanatory variable; α, β denotes the coefficient; GDP denotes the GDP per capita; and u denotes the error term following the normal distribution.

Results:

Meta regression analysis

Purpose of travel

- (Business) > (Work-to-school, Private, Leisure)

Attribute of travel

- (Access/egress, Wait, Transfer) > (Total travel)

Travel mode

- (Auto, Air) > (Rail, Walk) > (Bus, Ferry)

Type of data

- RP>SP

Urban/Inter-urban

- Inter-urban>urban

Variables	Coefficients	t-statistics
Purpose of travel (Baseline is business)		
Home-to-workplace	-0.08	-0.31
Home-to-school	-1.28	-4.08
Home-to-workplace and -school	-0.32	-1.16
Private	-0.74	-2.33
Leisure	-0.72	-1.89
Others	-0.53	-1.74
Attribute of travel (Baseline is total travel time)		
Access/egress time	0.63	3.23
Wait time at station of origin	0.72	2.92
Transfer time at station	0.66	2.52
Headway	-0.59	-2.01
Parking time	-0.79	-2.05
In-vehicle time	0.13	0.7
Walk time	0.32	0.83
Others	0.24	0.44
Mode-specific dummy variable		
Rail	0.1	0.47
Auto	0.62	2.91
Bus	-0.45	-2.36
Air transport	1.29	3.45
Ferry	-1.1	-2.3
Walk	0.12	0.46
Park & Ride	0.99	4.04
Type of data (Baseline is SP)		
RP	0.31	1.64
RP+SP	0.17	0.66
Urban/Inter-urban (Baseline is urban)		
Inter-urban	0.41	1.43

Results (Cont.): Meta regression analysis

- GDP per capita is significantly positive.
- GDP elasticity is 0.31.

Variables	Coefficients	t-statistics
Choice context (Baseline is modal choice)		
Route choice	0.36	1.45
Destination choice	-0.37	-0.99
Parking location choice	-0.02	-0.04
Airport choice	0.14	0.36
Type of model (Baseline is binary logit)		
MNL	-0.02	-0.12
MXL	0.15	0.4
Nested Logit	-0.35	-1.56
MNP	-0.34	-1.01
Others	-0.1	-0.41
Age (Baseline is 65 year-old or more)		
Less than 65 year-old	-0.46	-1.18
No data available	-0.44	-1.29
Research purpose (Baseline is VTTs estimation)		
Policy evaluation	-0.34	-1.69
Behavioral analysis	-0.15	-0.68
Cross dummy variable		
Air-route choice	-0.61	-1.58
Air-destination choice	0.47	0.87
Air-airport choice	0.37	0.41
Weekday/weekend day (Baseline is weekday)		
Weekend day	0.2	0.54
No data available	0.33	1.4
GDP per capita	0.31	2.23
Constant	2.05	2.5
R ²		0.66
Number of observations		261

VTTS estimations using the meta-regression model

Travel purpose vs. Age

	Business	H-to-W	Leisure
Less than 65	42.4	39.2	20.6
65 or over 65	26.8	24.7	13.0

Note: Route choice, MNL, total travel time, car-use, RP, and urban

Travel purpose vs. Travel type

	Business	H-to-W	Leisure
Total	25.2	23.3	12.3
Access/Egress	47.3	43.7	23.0
Wait at station	51.8	47.8	25.2
Transfer	48.8	45.0	23.7

Note: Route choice, MNL, rail-use, RP, less than 65 year old, and urban

VTTS estimations using the meta-regression model (continued)

Travel purpose vs. Data type

	Business	H-to-W	Leisure
RP	42.4	39.1	20.6
SP	31.1	28.7	15.1

Note: Route choice, MNL, total travel time, car-use, RP, less than 65 yrs, and urban

Travel purpose vs. Travel mode

	Business	Leisure
Air	91.6	44.6
Car	46.9	22.8
Rail	27.9	13.5
Bus	16	7.8

Note: Route choice, MNL, total travel time, RP, less than 65 year old, and inter-urban

VTTs estimation with SP data in Japan

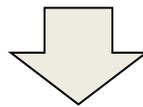
Motivation

- VTTs estimation with Stated Preference (SP) data
 - Very few experiences of SP-based VTTs estimation in Japan
 - Careful examination of SP survey design for VTTs estimation in the context of Japan
 - SP survey in Atsugi City with the paper-based and the web-based questionnaire sheets

Process of SP survey designing

Preparation of draft survey design

July 2010

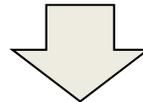


Group interview

August 2010

Interview with 6 individuals

Revision of survey sheet

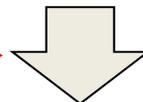


Preparatory questionnaire survey

September 2010

Paper-based questionnaire survey to 50 individuals

Revision of survey sheet



Main questionnaire survey

December 2010

Paper-based + web-based questionnaire survey to 3000 individuals

Estimation of VTTS with SP data

April to August 2011

Model estimation with 693 respondents data³⁹

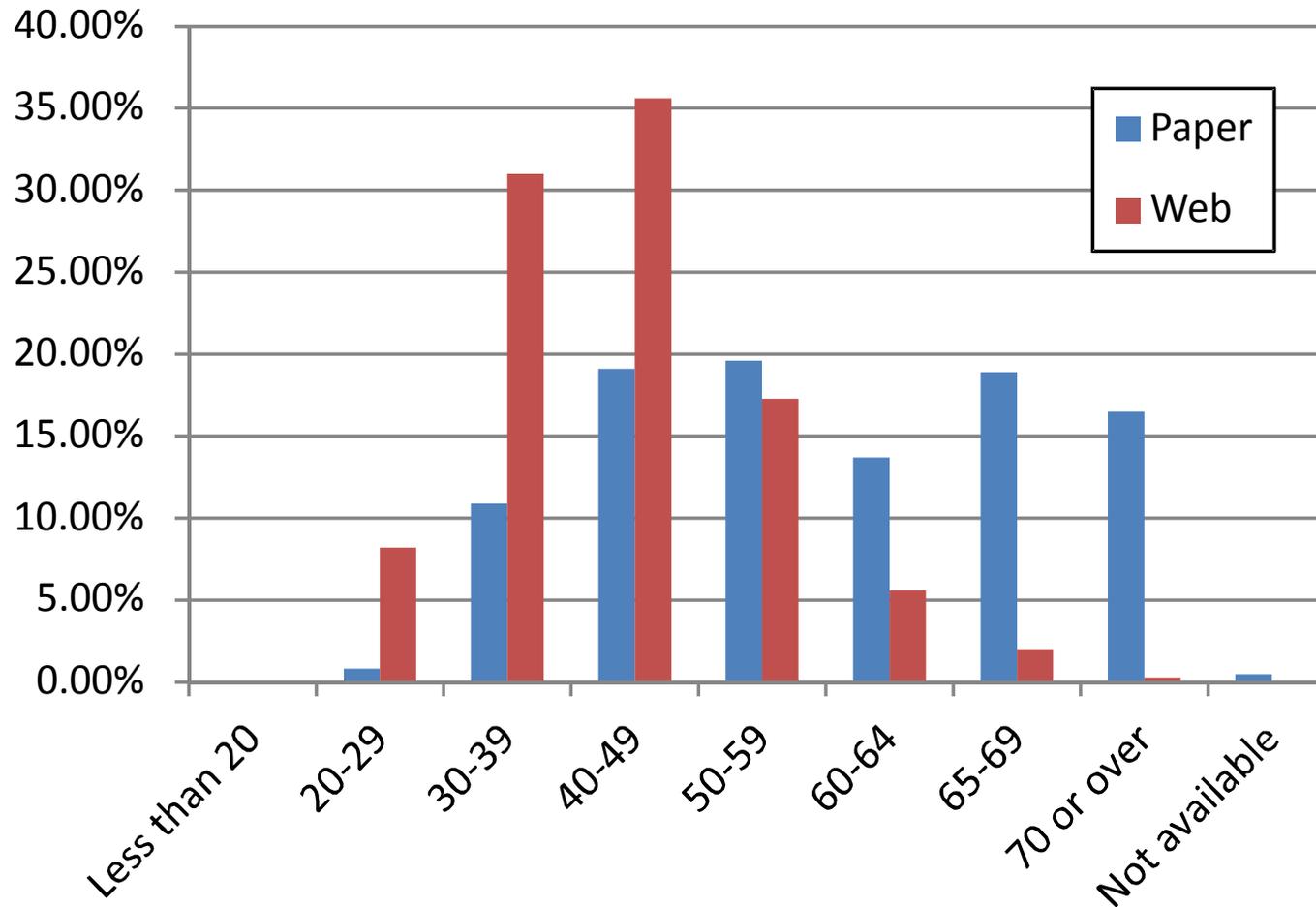
Sampling methods

- Paper-based survey
 - Randomly selected households
 - Direct posting for distributing survey sheets; postal mailing for collecting them
 - Survey was implemented in December, 2010
 - 3,000 sheets were distributed; 387 individuals responded (12.9%)
- Web-based survey
 - Internet monitors under the Internet search companies
 - Randomly selected from the Internet monitors who own cars
 - Survey was implemented in December, 2010
 - Data were collected from 306 respondents

Structure of survey sheets

- RP question: the latest travel episode using expressway
- Stated choice (SC) question: expressway route vs. no-expressway route
- Attributes in SC: 3 (Travel time in exp. route; travel time in no-exp. route; and travel cost in exp. route)
- Number of attribute levels in SC: 3 for travel time; 5 for travel cost
- Statistical design: fractional factorial design by random distribution of 9 patterns of sheets. Number of SC questions: 8 questions per sheet pattern. In total 24 questions.

Age distributions by survey method



The biases in age distributions will be adjusted with the weighted exogenous sampling maximum likelihood (WESML) approach.

Estimation of VTTs with BL

Binary logit: expressway route vs. no-expressway route

Utility functions

$$\text{Expressway route} \quad V_{h,n} = \beta_{TT} \cdot T_{h,n} + \beta_{TC} \cdot C_{h,n} + \beta_C$$

$$\text{No-expressway route} \quad V_{g,n} = \beta_{TT} \cdot T_{g,n}$$

$V_{i,n}$: Indirect utility function of route i for individual n

β_{TT} : Coefficient of travel time T

β_{TC} : Coefficient of travel cost C

$T_{i,n}$: Travel time of route i for individual n (Min.)

$C_{h,n}$: Travel cost of Expressway route (Yen)

SP+RP and Paper+Web combined estimation

“SP+RP” and “Paper+Web” mean the models in which the variance of error component in the utility function in one subgroup is assumed to be in proportion to that in other subgroup (Morikawa, 1989).

Utility functions by data type

$$\begin{aligned} V_{ni}^{P-RP} &= v_{ni}^{P-RP} + \varepsilon_{ni}^{P-RP} \\ V_{ni}^{P-SP} &= v_{ni}^{P-SP} + \varepsilon_{ni}^{P-SP} \\ V_{ni}^{W-RP} &= v_{ni}^{W-RP} + \varepsilon_{ni}^{W-RP} \\ V_{ni}^{W-SP} &= v_{ni}^{W-SP} + \varepsilon_{ni}^{W-SP} \end{aligned}$$

Assumptions of variance between data types

$$\begin{aligned} Var(\varepsilon_{ni}^{P-RP}) &= \mu_{PW}^2 Var(\varepsilon_{ni}^{W-RP}) \quad \forall i, n \\ Var(\varepsilon_{ni}^{P-SP}) &= \mu_{PW}^2 Var(\varepsilon_{ni}^{W-SP}) \quad \forall i, n \\ Var(\varepsilon_{ni}^{W-RP}) &= \mu_{RP+SP}^2 Var(\varepsilon_{ni}^{W-SP}) \quad \forall i, n \\ Var(\varepsilon_{ni}^{P-RP}) &= \mu_{RP+SP}^2 Var(\varepsilon_{ni}^{P-SP}) \quad \forall i, n \\ Var(\varepsilon_{ni}^{P-RP}) &= \mu_{PW}^2 \cdot \mu_{RP+SP}^2 Var(\varepsilon_{ni}^{W-SP}) \quad \forall i, n \end{aligned}$$

Logit-based probability by data type

$$\begin{aligned} P_{ni}^{P-RP} &= \frac{\exp(v_{ni}^{P-RP})}{\sum_j \exp(v_{nj}^{P-RP})} \\ P_{ni}^{P-SP} &= \frac{\exp(\mu_{RP+SP} v_{ni}^{P-SP})}{\sum_j \exp(\mu_{RP+SP} v_{nj}^{P-SP})} \\ P_{ni}^{W-RP} &= \frac{\exp(\mu_{PW} v_{ni}^{W-RP})}{\sum_j \exp(\mu_{PW} v_{nj}^{W-RP})} \\ P_{ni}^{W-SP} &= \frac{\exp(\mu_{PW} \cdot \mu_{RP+SP} v_{ni}^{W-SP})}{\sum_j \exp(\mu_{PW} \cdot \mu_{RP+SP} v_{nj}^{W-SP})} \end{aligned}$$

$$\max LL = \sum_{n=1}^{N^{P-RP}} \sum_{i=1}^{I_n^{P-RP}} \delta_{ni}^{P-RP} \ln P_{ni}^{P-RP} + \sum_{n=1}^{N^{P-SP}} \sum_{i=1}^{I_n^{P-SP}} \delta_{ni}^{P-SP} \ln P_{ni}^{P-SP} + \sum_{n=1}^{N^{W-RP}} \sum_{i=1}^{I_n^{W-RP}} \delta_{ni}^{W-RP} \ln P_{ni}^{W-RP} + \sum_{n=1}^{N^{W-SP}} \sum_{i=1}^{I_n^{W-SP}} \delta_{ni}^{W-SP} \ln P_{ni}^{W-SP}$$

Estimated VTTs

The estimated VTTs vary among the different data types.

Yen/Min		SP	SP+RP
Paper	H-to-W	16.6	17.0
	Business	51.9	45.5
	Private	26.5	24.0
Web	H-to-W	87.4	82.8
	Business	11.1	11.9
	Private	35.4	28.1
Paper + Web	H-to-W	20.6	27.5
	Business	45.3	39.1
	Private	30.7	25.4

SP only or SP+RP?

- VTTs estimated with the web-based survey data could not be stable.
 - This may be caused by inappropriate design of SP survey.
 - They may be improved by combining them with paper-based data.
- SP+RP estimation could lead to better VTTs estimation.

Achievements of our research project

- This project presented the evidences of VTTSs in Japan using the empirical data.
- We hope that the national VTTS will be discussed on the basis of our empirical analysis results.

Conclusions

Comparisons of VTTSs among different approaches

	RP estimation ¹	Meta analysis ²	SP+RP estimation ³
Business VTTS	33.9	42.4	36.7
% to business VTTS	100.0%	100.0%	100.0%
Home-to-work VTTS	24.5	39.2	25.8
% to business VTTS	72.3%	92.5%	70.3%
Private VTTS	21.0	20.2	23.8
% to business VTTS	61.9%	47.6%	64.9%

Note 1: The estimated results of BL model with the data of 2000.

Note 2: It assumes using a MNL model for car-use route choice with RP data on a weekday. In-vehicle VTTS is estimated using the meta-regression model (OLS) with the data of GDP per capita in 2000.

Note 3: The VTTS estimated with PW_RP+SP model is adjusted into 2000-year-value using GDP deflator.

Recommendations to the government

- Business VTTS: Cost-saving approach (wage-rate-plus)
- Non-business VTTS: introduction of the percentage approach (this is similar to US approach)
 - The percentage of non-business VTTS to business VTTS is estimated with RP-based VTTS estimation with national travel data regularly.
- Escalation of VTTS reflecting GDP growth

Further research issues

- Repeated VTTS analyses
 - Revision of VTTS estimation with the latest RP data
 - Methodological development of SP survey in the context of Japan
- VTTS estimation for other types of travels
 - Freight transportation
- International comparative analysis
 - Meta-analysis with multilateral database
 - Comparison of recent changes in VTTS among regions
- Transportation research and VTTS
 - Contributions to traffic demand analysis, transportation policy, and transportation planning

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