Variations of Value of Travel Time Savings

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Abstract

This paper theoretically and empirically examines variations of value of travel time savings in the intra-city travel. A time allocation model in mode or route choice case is presented. The concept of value of travel time savings is concluded from the proposed time allocation model and its variations are discussed. The appropriate functional form of discrete choice model is derived from the time allocation model. SP data related to the choice between a tolled route and a free route provides data source for the case study. Estimation results show the changes of value of travel time savings with travel time and individual socio-economic characteristics.

Keywords

Value of travel time savings, Time allocation model, Discrete choice model

Preferred citation

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1. Introduction

A great deal of attention has been made to study value of travel time savings (VTTS), because of its importance to transportation research. VTTS is a critical parameter in transport project appraisals due to its dominating factor in the user benefit. It is also a very important parameter to travel behaviour analysis and traffic assignment.

With the development of time allocation theory, the concept of the VTTS has been recently clarified more and more explicitly. From Becker (1965) to Jara-Diaz (2003), the concept of VTTS is developed from the same value to all non-work activities to the specific value for each activity. De Serpa (1971) concluded that value of time savings (VTS) consists of value of time as a resource (VTR) (i.e., value of re-assignment of time to other activities) and value of time as a commodity (VTC) (i.e., value of time allocated to a certain activity). In addition to the two components, recently Jara-Diaz (2003) proposed the third component that value of changes in the consumption patterns. Consequently, VTTS is expected to vary with travel and individual socio-economic (SE) environments. However, the variation mechanism of VTTS is still unclear only with few studies on it (De Serpa, 1971; De Donnea, 1972; and Kono and Morisugi, 2000.). But the analyses by De Serpa and De Donnea were limited to the income effect. Although Kono and Morisugi (2000) analysed most complete environmental effects, their research only considers a special case of travel and only one part of VTTS-VTR. As a result, it is difficult to design empirical experiments and to explain the various results observed from the empirical studies. Until now, empirical studies have shown less consistent results in the variations of VTTS, even showing conflicting evidence in the relationship of VTTS to travel time (for example, Hensher, 1997; Gunn, 2001.).

This paper focuses on the theoretical and empirical examination on how the travel and individual socio-economic (SE) environments influence VTTS. The mode or route choice in the intra-city daily travel is studied. First, based on the microeconomic consumer behaviour theory, a time allocation model is proposed for the mode or route choice case of travel behaviour. The relationships of VTTS to travel time, travel cost, and individual SE characteristics are discussed analysing the change of each component of VTTS. Second, the functional form of discrete choice model is derived. The variation analysis helps specify the appropriate functional form of the choice model. Stated preference data related to the choice between a tolled route and a free route are used for the case study. The analysis results are summarized at last.

2. Time Allocation Model

The roles of time in the utility function and constraints are the main issues in the construction of time allocation model. According to the different uses of time, in a daily life, activities can be divided into three kinds, work, travel, and leisure. We assume that other time except work and travel is leisure time in which individual wish to assign more time than required (De Serpa, 1971). A reduction in travel time is equivalent to an increase in the effective time available for leisure if retiming is available. Usually work time can be viewed as fixed. In this case, work time is assumed to create no utility, because the subjective value of work time can influence the content of VTR. This has no direct effect to the change of VTR and VTTS. Travel time is included into the utility function since travelling usually causes fatigue and discomfort. Therefore, the individual utility is composed of goods consumption, leisure time, and travel time.

Travel time is usually an exogenous variable. Following De Serpa (1971) a time consumption constraint is included in addition to the income and time resource constraints in order to fulfil the exogenous property of this variable. Travel cost can be viewed to be independent to travel time in the intra-city travel especially in the study of stated preference (SP) data. According to these considerations, the following time allocation model is presented.

$$\max u = u(p_l, t_l, t_i) \tag{1a}$$

$$\text{S.t. } p_l + p_i = wt_w \tag{1b}$$

$$t_l + t_w + t_i = T \tag{1c}$$

$$t_i \geq \overline{t_i} \tag{1d}$$

where, p_l is the cost of composite goods consumed at leisure activities, t_l is leisure time, t_i is travel time by mode or route i, p_i is travel cost by mode or route i, w is wage rate, t_w is work time assumed exogenous, T is the available time, $\overline{t_i}$ is the minimum time requirement of mode or route i.

The first constraint is a standard budget constraint associated to a multiplier λ that represents the MU of income. The second constraint is a time constraint associated to a multiplier μ that represents the MU of time resource. The third constraint implies that travelling by any mode or route requires some minimum amount of time be allocated to it. But the individual may spend more time if he so desires. So each mode or route is associated with a minimum time requirement. The multiplier k_i is the MU of decreasing the time requirements of mode or route i called as MU of time savings. According to the consideration of travelling as an intermediate activity, in which individuals are not freely willing to commit more time than required, the third constraint is binding for travel.

The Lagrangian of the mathematical program can be written as

$$L = u(p_l, t_l, t_i) + \lambda(wt_w - p_l - p_i) + \mu(T - t_l - t_w - t_i) + k_i\left(t_i - \overline{t_i}\right) \tag{2}$$

The first order conditions are

$$\frac{\partial u}{\partial p_l} = \lambda \tag{3a}$$

$$\frac{\partial u}{\partial t_l} = \mu \tag{3b}$$

$$\frac{\partial u}{\partial t_i} = \lambda p_i^{'} + \mu - k_i \quad (3c)$$

According to the De Serpa's definition, VTR is

$$\frac{\mu}{\lambda} = \frac{1}{\lambda}\frac{\partial u}{\partial t_l} \quad (4)$$

and VTTS is

$$\frac{k_i}{\lambda} = \frac{\mu}{\lambda} - \frac{1}{\lambda}\frac{\partial u}{\partial t_i} \quad (5)$$

The first term of the left side of equation (5) is VTR, i.e., value of saved time used to leisure. If leisure time can be viewed as normal goods, marginal utility (MU) of leisure time decreases. As shown in figure 1, MU of leisure time caused by travel time savings will increase with travel time. On the other hand, since travel cost is independent to travel time, MU of income is stable to travel time. Therefore, VTR will increase with the increase of travel time.

The second term of the left side of equation (5) is VTC. MU of travel time is usually viewed to be negative, since travelling produces disutility such as fatigue and discomforts. However, whether MU of travel time increase or decrease with travel time is unclear. If MU of travel time decreases ($\partial u^2 / \partial t_i^2 < 0$), VTTS will increase since VTR increases and VTC decreases. On the other hand, when MU of travel time increases ($\partial u^2 / \partial t_i^2 > 0$), VTTS is also possible to increase if one is more sensitive to the benefit change of leisure time lost than that of travel time gained (i.e., increase of VTR is greater than increase of VTC). However, if one is more sensitive to the benefit change of travel time gained than that of leisure time lost (i.e., increase of VTC is greater than increase of VTR), VTTS will decrease. In the common intra-city travel, the last case is expected to be the most possible to occur. This is because travel time is much shorter than leisure time in a short trip. Therefore, the influence of unit time change to MU of travel time is expected to be greater than the influence to MU of leisure time.

Furthermore, VTTS will decrease with travel cost, since increase of travel cost causes increase of MU of income. However, in the intra-city travel, travel cost is very small and has little influence to the amount of available money. Therefore, the effect of travel cost can be ignored. On the other hand, VTTS will increase with income level, since increase of income relaxes the income constraint (i.e., λ decreases). In addition, VTTS also varies with journey purposes, since different journey imposes different evaluations to time and money. The case study made in this paper is aimed to empirically examine how VTTS varies with these factors in the intra-city travel, and make clear the reasons behind the variations.

Figure 1 Change of MU of Leisure time with travel time

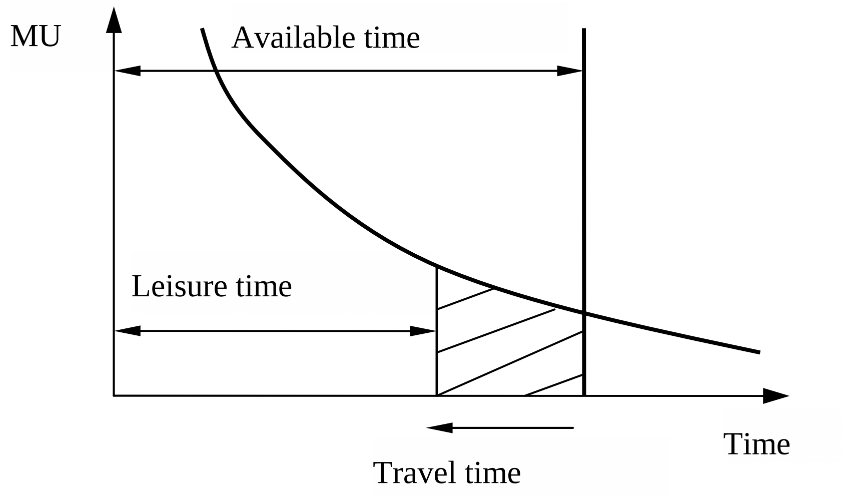
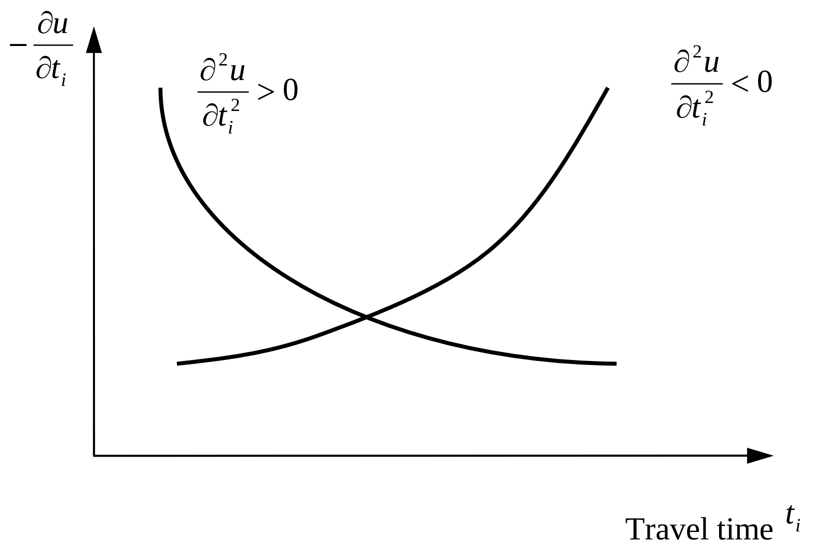


Figure 2 Change of MU of Travel Time



3. Modelling Approach

There are two main modelling approaches for measuring the variation of VTTS in discrete choice analysis. One is to specify the functional form of the model based on the economic model. One typical study was made is Hensher (1997). In order to see any changes of VTTS with the level of travel time and cost, Hensher assumed k_i as a function of travel time and cost. Hultkrantz and Mortazavi (2001) derived a second order approximation to the difference of utility functions to see the effects of trip length and SE variables. By reviewing the British VTTS studies, Wardman (1998, 2001) show the efforts made to conclude specific values with attribute levels and modes, according to their segmentation. The second modeling approach used a less constraining specification. For example, Ben-Akiva (1994) assumed a randomly distributed VTTS in estimating the discrete choice model. In Hensher (2001), parameters of travel time and travel cost were assumed randomly distributed (normal and logarithmic). De Lapparent and De Palma (2002) proposed a Box-Cox Logit Model indicating uncertainties of marginal utilities. The first approach shows specific values with levels of attributes but in a pre-specified, original, logarithmic, or quadratic form. On the other hand, the second approach concludes a distributed VTTS with levels of attributes.

In order to see changes of VTTS with levels of attributes, in this paper, the functional form of the discrete choice model is specified according to the proposed economic model. This specification is based on the recent development on the relationship of the discrete choice model to the time allocation theory (Train and Mc Fadden, 1978; Bates, 1987; and Blayac and Causse, 2001.). Train and Mc Fadden (1978) demonstrated that indirect utility of the consumer behaviour model is the representative utility to describe an alternative in the discrete choice model. Bates (1987) derived the representative utility functions from the first order approximation of the indirect utility. According to the derivation, Bates indicated that the marginal rate of substitution (MRS) of time and cost in the discrete choice model could represent VTTS. But MU of income and time were assumed to be constants causing constant VTTS. Recently, Blayac and Causse (2001) theoretically legitimised non-linear representative utilities by deriving them from the total differential of the indirect utility. In their research, the assumption of constant MU is relaxed. Instead, a first order Taylor expansion is used to the MU. But the first Taylor expansion yields merely high-order functional forms. In this paper, the functional forms of the representative utility are proposed according to the variation analyses made in the previous section.

Substituting optimum solutions to the Lagrangian, we can get the indirect utility of the maximization problem. This indirect utility can be used to describe the representative utility of the discrete choice model. The optimum solutions of λ^*, μ^*, k_i^*, p_l^*, t_l^*, and t_i^* are functions of $\mathbf{x} = \{w, t_w, T, \overline{t_i}, p_i\}$. Therefore, the representative utility can be described as a function of $\mathbf{x}$. Let $V_i(\mathbf{x})$ be the representative utility function of alternative i.

$$V_i(\mathbf{x}) = u\left(p_l^*, t_l^*, t_i^*\right) + \lambda^*(\mathbf{x})\left(wt_w - p_l^* - p_i\right) + \mu^*(\mathbf{x})\left(T - t_l^* - t_w - t_i^*\right) + k_i^*(\mathbf{x})\left(t_i^* - \overline{t_i}\right) \qquad (6)$$

Defined as the willingness to pay for a unit time saving, VTTS can be measured as the MRS between travel time and travel cost.

$$\frac{\partial V_i / \partial \overline{t_i}}{\partial V_i / \partial p_i} = \frac{k^*(\mathbf{x})}{\lambda^*(\mathbf{x})} \qquad (7)$$

Based on Bates (1987), the first order of the direct utility function is used to approximate the representative utility.

$$V_i = a_i + \left.\frac{\partial u}{\partial p_l}\right|_{p_l^*} p_l^* + \left.\frac{\partial u}{\partial t_l}\right|_{t_l^*} t_l^* + \left.\frac{\partial u}{\partial t_i}\right|_{t_i^*} t_i^* \tag{8}$$

Substituting equation (1b) and (1c) into equation (8) yields

$$V_i = a_i + \lambda^*(\mathbf{x})(wt_w - p_i) + \mu^*(\mathbf{x})(T - t_w) - k_i^*(\mathbf{x})\overline{t_i} \tag{9}$$

Equation (9) shows that the representative utility is a function of $w, t_w, T, \overline{t_i}$, and p_i. Furthermore, the perception of travel environments ($\partial u/\partial t_i$) varies among individuals according to their age or sex. Therefore, the representative utility can be described as a function of individual SE attributes and lever of service (LOS).

$$V_i = a_i + f(SE, LOS; p_i) + g\left(SE, LOS; \overline{t_i}\right) \tag{10}$$

The functional forms of f and g in equation (10) are dependent on the functional form of direct utility, which is unclear. However, it is clear that these functions are functions of individual SE variables and non-linear functions of travel time. In this case study, more general assumptions are supposed to the functional forms according to the predicted variations of VTTS and the choice environments.

4. Case Study

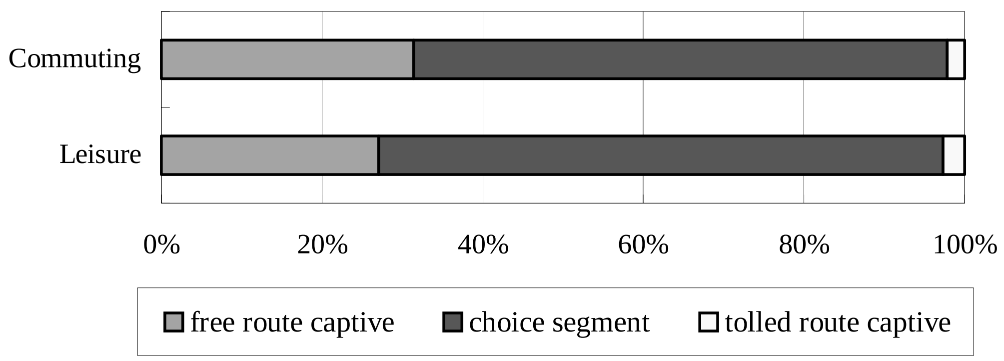
4.1 Data Description

SP data collected by National Person Trip Survey (1999) are used for this case study. Two kinds of travel purposes, commuting and travelling for leisure, are studied. Two choice alternatives, a tolled route and a free route, are provided. Twelve choice patterns of LOS are provided as shown in table 1. The number of samples for commuting is 7699 and for shopping is 13688. All respondents can be divided into three segments according to their choice behaviors, a free route captive (i.e., one chooses the free route through all twelve patterns), a choice segment (i.e., one chooses different routes in different patterns), and a tolled route captive (i.e., one chooses the tolled route through all twelve patterns). The percentage of each segment is shown in figure 3.

Table 1 Choice Patterns of Level of Service

Free route		Tolled route	
Time	Cost	Time	Cost
40mins	0 yen	30mins	100,300,500,700yen
50mins	0 yen	30mins	200,400,600,800yen
60mins	0 yen	30mins	300,600,900,1200yen

Figure 3 Percentages of Captives and Choice Segment



4.2 Discrete Choice Model

Table1 and figure1 show that about 30% of respondents belong to the free route captive because their VTTS is lower than 10JPY/min or because of other unknown reasons. On the other hand, about 2% of respondents belong to the tolled route captive, because their VTTS is higher than JPY/min or because of other unknown reasons. No choice behaviour can be observed from the captives. Considering behaviour differences between the captives and the choice segment, a latent class (LC) model is proposed. This LC model consists of two submodels, a membership model and a route choice model. In the membership model, the probability that an individual belongs to each segment is estimated. Meanwhile, the route choice model describes the choice behaviour of the choice segment.

4.2.1 Membership Model

It can be predicted only in a probability that which segments an individual belongs to. Here, an individual is assumed to belong to the segment that maximizes the following membership function, which is described by individual SE characteristics and a probability term.

$$M_{in} = \alpha_{oi} + \mathrm{A}X_{in} + \varepsilon_{in} \quad i=1, 2, 3 \tag{11}$$

in which, $i=1, 2, 3$ indicate the free route captive, the choice segment, and the tolled route captive respectively, M_{in} is the membership value of segment i for nth individual, A is deep parameter vectors, X_{in} is a vector of individual SE variables, and ε_{in} is an error term assumed as IID Gumbel distributed. According to this membership function, the membership probability that an individual belongs to each segment can be calculated as

$$Q_{in} = \frac{\exp(\alpha_{0i} + AX_{in})}{\sum_{j=1}^{3}\exp(\alpha_{0j} + AX_{jn})} \tag{12}$$

4.2.2 Route Choice Model

According to equation (10), an exponential function is assumed for the route choice model in order to examine the effects of travel time and individual SE characteristics.

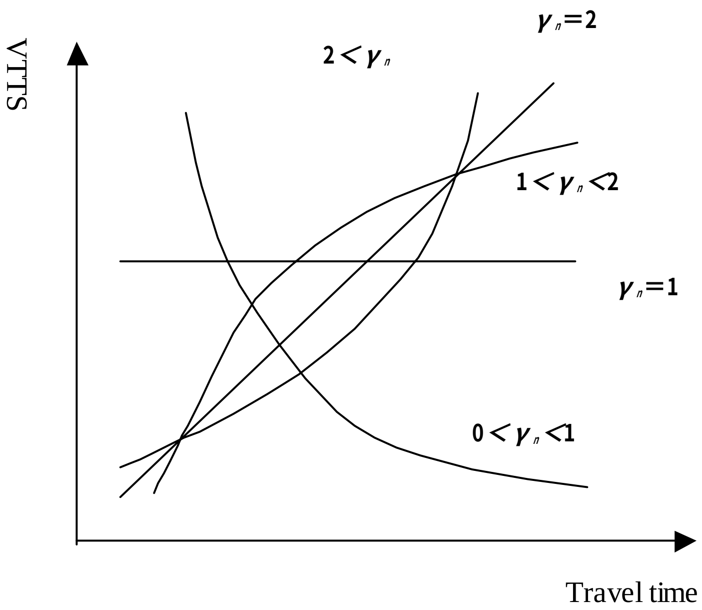
$$U_{kn} = \beta_{o,kn} + \beta_{1,kn}c_{kn} + \beta_{2,kn}t_{kn}^{\gamma_n} + \varepsilon_{kn} \tag{13}$$

$$\beta_{1,kn} = BY_{kn} \ , \ \gamma_n = \frac{\eta\exp(CZ_{kn})}{1+\exp(CZ_{kn})}$$

here, U_{kn} is the utility of alternative k for nth individual, $\beta_{0,kn}, \beta_{1,kn}, \beta_{2,kn}$ are parameters, B, C are deep parameter vectors, Y_{kn}, Z_{kn} are vectors of individual SE variables, c_{kn} and t_{kn} are travel cost and time of alternative k for nth individual, γ_n is a positive parameter of nth individual which explains individual's sensibility to time, η is an exogenous variable which represents maximum value of γ_n, and ε_{kn} is an error term assumed as IID Gumbel distributed.

According to the variation analysis made in section 1, the utility function should be a non-linear function of travel time. Also the change of VTTS differs among individuals. But the exact functional forms of the changes are unclear. In order to reflect these properties, the travel time term is assumed to be an exponential function as shown in equation (13). As shown in figure 4, the exponential function is able to measure not only whether VTTS increases or decreases, but also whether the functional form of VTTS is concave or convex. A logit functional form is used to avoid divergence of γ_n. Given the value of η exogenously, γ_n will be determined endogenously through the maximum likelihood estimation on the data set. According to figure 4, η is requested to be lager than 2 in order to provide enough range of γ_n. Individual SE variables such as profession, age, and sex are taken into consideration.

Figure 4 Function Type of VTTS According to γ_n



4.2.4 Latent Class Model

According to the membership model and route choice model, the probabilities of an individual choosing the free route and the tolled route will be the sum of the probabilities of choosing these routes in each segment. The probability of choosing the free route and the tolled route in choice segment can be derived from the route choice model. In the free route captive, the probability of choosing free route is equal to 1, because the free route captive produces no other choice except free route. Oppositely, this probability is zero in the tolled route captive. In the same way, the probability of choosing tolled route is equal to 1in the tolled route captive and is zero in the free route captive. The probability of choosing the free route and the tolled route are described in equation (14) and (15) respectively.

$$P_{fn} = P_{fn/1n}Q_{1n} + P_{fn/2n}Q_{2n} + P_{fn/3n}Q_{3n} \tag{14}$$

$$P_{fn/1n} = 1,\ P_{fn/2n} = \frac{\exp(U_{fn})}{\exp(U_{fn} + U_{tn})},\ P_{fn/3n} = 0$$

$$P_{tn} = P_{tn/1n}Q_{1n} + P_{tn/2n}Q_{2n} + P_{tn/3n}Q_{3n} \tag{15}$$

$$P_{tn/1n} = 0\,,\ P_{tn/2n} = \frac{\exp(U_{fn})}{\exp(U_{fn} + U_{tn})}\,,\ P_{tn/3n} = 1$$

here, P_{fn} and P_{tn} are the probabilities of choosing free route and tolled route respectively, $P_{fn/in}$ and $P_{tn/in}$, $i = 1,2,3$ are the probabilities of choosing free route and tolled route in each segment, and U_{fn} and U_{tn} are the choice utilities for the free route and the tolled route as described in equation (13).

This LC model is estimated by maximum likelihood method. When using non-linear form of utility function, it is difficult to assure that the likelihood function is globally concave. In this research all the parameters showed consistent values with different values of η and different start values of all other parameters. Therefore, the estimation results can be viewed as global optimum solutions.

4.2.5 Value of Travel Time Savings

According to the LC model, VTTS for an individual will be

$$VTTS_n = \sum_{i=1}^{3} VTTS_{in} \times Q_{in} \tag{16}$$

For the choice segment, VTTS can be calculated as the MRS of travel time and cost.

$$VTTS_{2n} = -\frac{\partial U_{kn} / \partial t_{kn}}{\partial U_{kn} / \partial c_{kn}} \tag{17}$$

However, for the free route captive and the tolled route captive, it is difficult to conclude adequate functional form of VTTS. According to the data sets used, VTTS is assumed to be 10JPY/min for the former (the highest value for the free route captive) and 70JPY/min for the latter (the lowest value for the tolled route captive).

4.3 Result Analysis

The estimation results are presented in table 2. Male dummy, age 65+ dummy, and several kinds of worker dummies are included into the model as individual SE variables. According to the professions, the respondents are divided into three kinds of workers. In the commuting case, they are divided into farmer and fisher, blue collar, and white collar. On the other hand, in the leisure case, they are divided into unemployed, blue collar including farmers and fishers, and white collar.

Values of γ_n are summarized in table 3. VTTS for commuting and leisure are summarized in table 4 and table 5 respectively. Figures 5 and 6 show changes of VTTS with travel time, age, and licensed or not. Differences in VTTS between commuting and leisure are shown in figure 7.

Table 2 Model Estimation Results (t-statistics in parentheses)

		Commuting		Leisure	
Membership model					
Free route captive	Constant	2.17	(25.1)	2.55	(18.9)
Choice captive	Constant	2.63	(14.6)	4.44	(21.5)
	Male dummy	-0.127	(-2.0)	-0.582	(-8.5)
	Farmer and fisher dummy	–	(–)	–	(–)
	Blue collar worker dummy	0.738	(4.7)	–	(–)
	White collar worker dummy	1.08	(6.8)	0.327	(6.0)
	Unemployed dummy	–	(–)	-0.482	(-7.1)
Route choice model					
Free route constant		3.36	(27.6)	3.04	(42.9)
Cost (1000JPY)	Constant	-4.38	(-21.7)	-3.73	(-35.1)
	Age 65+ dummy	1.63	(6.7)	0.801	(7.1)
	Male dummy	0.393	(7.4)	0.304	(9.3)
	Licensed dummy	-1.04	(-5.5)	-0.915	(-9.5)
Time (hour)		-13.9	(-11.5)	-12.1	(-22.0)
γ_n	Constant	-1.63	(-13.8)	-1.54	(-24.8)
	Age 65+ dummy	-0.353	(-6.0)	-0.251	(-8.7)
	Licensed dummy	0.269	(6.1)	0.362	(12.6)
Number of samples		7699		13688	
Goodness of fit $\bar{\rho}^2$		0.388		0.339	

Table 3 Values of γ_n (Values for 65+ in parentheses)

	Commuting	Leisure
Licensed	1.02 (0.76)	1.18 (0.97)
Not licensed	0.82 (0.61)	0.88 (0.72)

Table 3 shows that γ_n varies with age, licensed or not, and travel purposes. VTTS of a blue-collar man are illustrated in figures 5 and 6 giving an example of the changes of VTTS. These figures and tables show that

- γ_n changes with age. The senior who is older than 65 has lower γ_n than the junior who is younger than 65. This means that the senior is more sensitive to the change of travel time. Also, γ_n is always less than 1 for the senior. As shown in figure 4.2, $\gamma_n < 1$ means that VTTS decreases with travel time. This is also evident from figures 4.3 and 4.4. Furthermore, decrease of VTTS verifies that MU of travel time increases ($\partial u^2 / \partial t_i^2 > 0$) for the senior as discussed in section 4.1.
- γ_n changes with licensed or not. A potential reason of the change is to what position an individual put himself when he responds to the stated scenario, a driver or a passenger. A licensed person may put himself as a driver and a not licensed person may put himself as a passenger. Therefore, the difference between licensed or not can be explained as the difference between a driver and a passenger. This difference can only be caused by different perceptions to the comfort of traveling. The higher value for a driver verifies the effect of greater disutility that the driver suffers.
- $\gamma_n > 1$ for who is younger than 65 and has license, but $\gamma_n < 1$ for others. Only with this, we cannot affirm that MU of travel time for the licensed and younger than 65 decreases ($\partial u^2 / \partial t_i^2 < 0$). However, it is clear that MU of travel time for them has little decreasing change than that for others. This is reasonable since a driver usually suffers greater fatigue. $\gamma_n < 1$ for a senior driver because the senior is more sensitive to the change of travel time.
- γ_n is higher for leisure than commuting. If there is the same discomfort level between the two cases, it is clear that an individual is more conscious of leisure time lost in the leisure than in the commuting. Therefore, the effect of the decrease of VTC becomes subtle in the travelling for leisure. Consequently, the decreasing change of VTTS becomes more relaxed in the leisure travel.

Figure 5 Changes of VTTS with Travel Time in Commuting

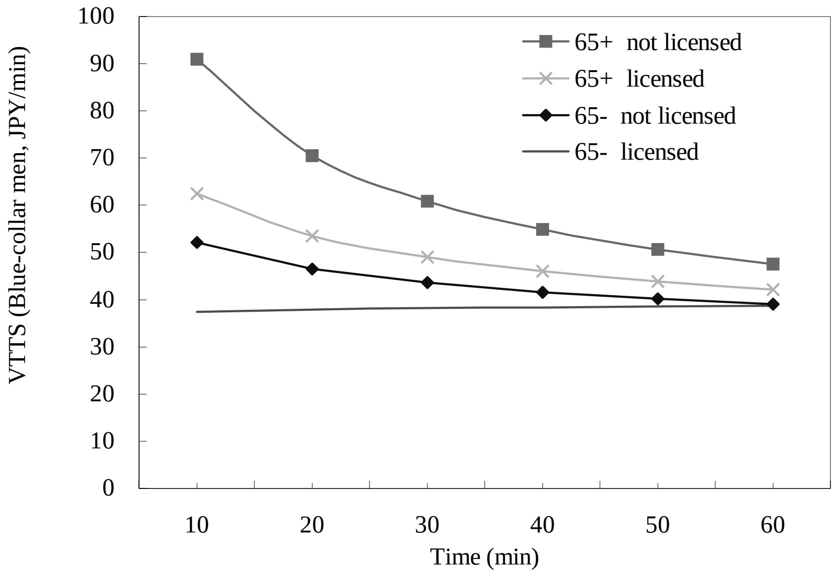


Figure 6 Changes of VTTS with Travel Time in Travelling for Leisure

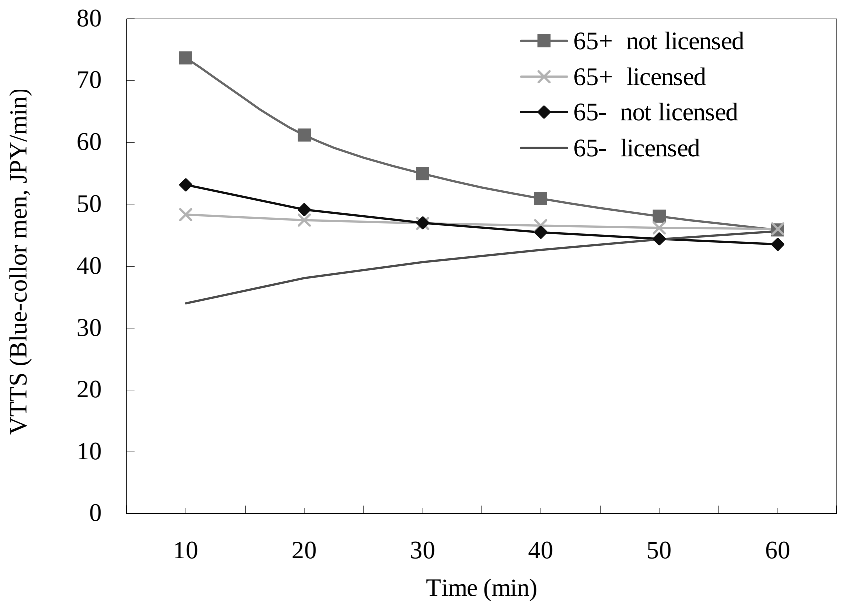


Table 4 VTTS in Commuting (JPY/min) (Values for 65+ in parentheses)

	Time = 30min		Time = 60min	
According to sex				
Female	31.98	(38.95)	32.33	(34.00)
Male	32.97	(41.42)	33.33	(36.17)
According to income level				
Farming and Fishing	32.97	(41.42)	33.33	(36.17)
Blue Collar	38.20	(48.98)	38.67	(42.17)
White Collar	39.99	(51.92)	40.50	(44.50)
According to driver or passenger				
Licensed	39.99	(51.92)	40.50	(44.50)
Not licensed	45.98	(64.87)	41.00	(50.33)

Table 5 VTTS in Travelling for Leisure (JPY/min) (Values for 65+ in parentheses)

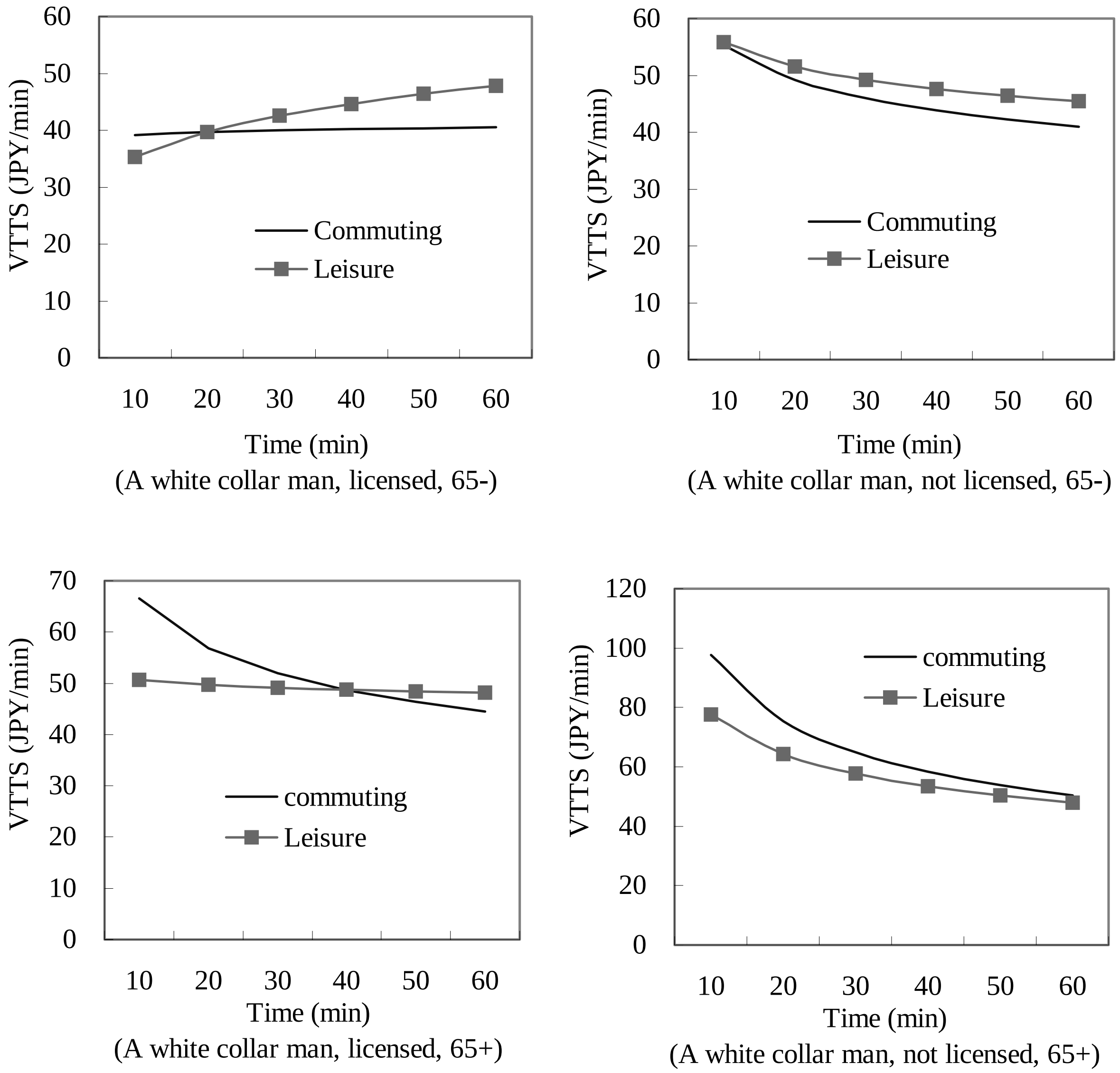
	Time = 30min		Time = 60min	
According to sex				
Female	38.75	(44.01)	43.50	(43.17)
Male	37.62	(42.95)	42.00	(42.17)
According to income level				
Unemployed	37.62	(42.95)	42.00	(42.17)
Blue Collar	40.68	(46.90)	45.67	(46.00)
White Collar	42.52	(49.13)	47.83	(48.17)
According to driver or passenger				
Licensed	42.52	(49.13)	47.83	(48.17)
Not licensed	49.23	(57.75)	45.50	(48.00)

As shown in tables 5 and 6, VTTS varies with individual SE characteristics such as age, sex, level of income, and licensed or not.

- According to age, a senior (65+) has a higher VTTS than a junior in both commuting and travelling for leisure. This is caused partly by the less evaluation of cost (i.e., the parameter of the age 65+ dummy in the cost term is larger than 0) and partly by the higher sensitivity to the disutility of travelling (i.e., γ_n is lower for a senior than for a junior).
- VTTS varies little with sex. The male dummy affects the cost term but no other terms.
- VTTS increases with the level of income. This is consistent with the theoretical analysis.
- A licensed person has a lower value than a not licensed person. This can explain that a driver has lower value than a passenger. This is caused partly because of by the higher evaluation of cost (the parameter for the licensed dummy in the cost term is less than 0) and partly because of the lower sensitivity to the change of travel time (γ_n is smaller for a driver than for a passenger).

Figure 7 shows the differences of VTTS between commuting and traveling for leisure. VTTS is higher for leisure than commuting for juniors but opposite for seniors. This reflects that leisure activities are more highly evaluated than commuting in the young generations. Furthermore, figures 5 - 7 show that differences among individuals decrease with travel time.

Figure 7 Comparison of VTTS between Commuting and Travelling for Leisure



5. Summary

This paper measures the changes of VTTS with travel time and individual SE environments in the intra-city travel. The proposed time allocation model is a simple transformation of De Serpa's framework to the study of travel activity. Because travel cost is independent to travel time in this case, it was easy to analyse the change of VTTS theoretically. In the variations of

VTTS, the effect of changes in VTC is the most controversial one. Understanding the change of VTC needs more empirical and psychological approaches. The exponential function of route choice model makes it possible to reflect perception differences among individuals, imposing less restriction on the functional form of VTTS. A LC model is proposed according to the property of data set. The estimation results show that VTTS differs greatly from individual to individual, but the difference becomes small as travel time increases. Furthermore, the decrease of VTTS with travel time provides empirical evidence to the change of MU of travel time that it decreases with travel time in most cases. Future researches on analysing the change of VTTS including the effect of value of changes in the consumption patterns are expected.

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