ANALYSIS ON USER'S PERCEPTION OF TRAVEL TIME SAVING BENEFIT USING ACTIVITY BASED APPROACH

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Abstract: In identifying the travel time saving benefit, there is an issue in Japan explaining that value of time saving is considered higher during weekends than on weekdays. The primary reason for this is that people have limited time in the weekend to spend for activities that are difficult to do on a weekday, in particular, recreational activities with family. Beside economic or monetary approach, it seems that there is a need to analyze value of time saving from a different point of view. In dealing with this, surveys have been conducted and a utility-of-activity model that takes psychological needs as variables is proposed. The model aims to predict the time allocation change as a result of time saving.

Keywords: Activity, needs, utility, extension choice, value of time.

1. INTRODUCTION

The value of travel time saving during holidays in Japan is considered more expensive than on weekdays. The current guideline for value of time for passenger car in weekday is 56 yen/vehicle/minute or 3360 yen/vehicle/hour (31.70 US $), and 84 yen/vehicle/minute or 5040 yen/vehicle/hour (47.55 US $) for weekends. The primary reason for a higher value of weekend time in the Japanese case is that people have limited time in the weekend to spend for activities that are difficult to do on a weekday, in particular recreational activities with family.

The budgeting also helps explain this situation because weekend holiday wages for employees are 35%~50% higher than weekday wages, and charges for accommodations are 20~30% higher on holidays. From the vehicle capacity point of view, the average number of passengers in passenger car is almost 1.44 on weekday, while it is 2.01 on holiday. Nevertheless in order to explain better about this phenomenon, it seems that there is a need to analyze it from a different perspective, instead of relying only on economic or monetary approach.

The benefit of travel time saving has been more represented in economic benefit, such as production time extension. Recently, as in Kitamura (1997), there is a tendency to also explain the benefit in terms of social welfare and psychological benefit using the activity based approach. This approach is considered able to explain the phenomenon that occurs in Japan.

1.1 Literature Review

Many previous researches on travel time benefit have applied trip-based approaches, which deal with utility/disutility of travel, travel time, and psychological or physical discomfort during the trip. However, the current trend in transport researches is the application of activity-based approach, that is, the activity being the reason for travel. The purpose of this research is for time use analysis, which will later on contribute to the activity based travel analysis. "Broadly, activity based analysis attempts to better understand the behavioral basis for individual. This behavioral basis includes all the factors that influence the how, where and why of performed activities. Among these factors are the needs, preferences, prejudices and habits of individuals" (Bhat and Koppelman, 1999). The related theories in this research are motivational theory, consumer theory with cumulative utility function, and discrete choice. Motivational theory, the first approach, was defined by Maslow (1970) and he stated that "the human being is motivated by a number of basic needs which are species wide, apparently unchanging, and genetic of instinctual in origin. They are intrinsic aspects of human nature which culture cannot kill, but only repress". On the average, for individual workers, and so-called commuters, their basic physical needs such as food and shelter are assumed to be fulfilled, assuming stable income condition. The higher needs that they would like to achieve then are the mental achievements, such as love, self-esteem, and meaningfulness.

Solomon and Ben-Akiva (1983) realized this symptom with their opinion about life style. According to them, life style is basically choice between family formation, participation in labor force, and orientation toward leisure. The life style choice will influence the choice of mobility in terms of employment location, residential location, housing type, and automobile ownership. Consequently, these choices will influence the activity and travel choice (non-work) such as activity type, activity duration, destination, route, and mode.

From the viewpoint of economic theory, Becker (1965) stated, "The household is both a producing unit and utility maximizer. The integration of production and consumption is at odds with the tendency for economists to separate them sharply, production occurring in firms and consumption in households".

According to demand behavior theory, consumer is considered to choose between two goods, consumption and labor. Consumption will maximize one's utility as a function of goods consumed, and it is considered that an increase in wage rate tends to increase the supply of labor since it makes leisure more expensive, but at the same time, the increase in the wage rate makes individual richer, and this presumably increases the demand for leisure.

1.2 Research Objectives

Several questions or considerations are raised in this research. When economists consider the double role of households, what would the households think of themselves? Do households consider time an input for production or consumption? It is difficult to observe if someone really likes and enjoys working; while the economists may look at it as a producing action, the person may think that it is a consuming action with time as an input, thereby maximizing her mental utility. So whether time is considered as an input of production or consumption depends on the households.

After the mandatory working hours are finished, an individual may be offered a choice of consumption of market goods and services including extending or continuing working. Is the time considered a resource or a commodity? Is that a matter of production or consumption, working or leisure (non-working)? Who is decides this, a producer or a consumer? In a more focused question, what do they need time for at the most?

In light of these premises, firstly, this research would like to explore time saving impact on time allocation from the consumer's point of view. The results of a survey conducted in Tokyo (discussed in the next section) will provide a support to the idea of having a method of

predicting time allocation based on their intentions and stated preferences. Secondly, this research would like to propose a model that could predict time allocation change taking into account the needs of the individual.

2. SUPPORTING DATA ON INDIVIDUAL TIME ALLOCATION - A STUDY IN TOKYO

2.1 Survey for Time Use, Priorities and Extension Choice in Tokyo, Japan

A survey on time use, priorities, and extension choice was conducted in Aqua-Line Toll Bridge/Tunnel Road that connects two sides of the Tokyo Bay last December, 2000. The questionnaires were distributed during weekend at the two ends of the bridge and respondents were asked to mail them back. From the total number of respondents, 413 are working in Tokyo (88% are male). These workers will be the focus of the analysis because they are considered as the most typical individuals that use transportation service regularly. They are also the ones who have the most typical pattern of weekday activity and are the most exposed to repeated travel activity (which is considered in this research as a disutility). From the 413 respondents, 266 persons belong to families with children. Since the main interest of this research is related with time allocation of family activity and need for family care, the 266 samples are considered relevant for the analysis. The profile of respondents is shown in Figure 1.

The questions asked were about individual priorities, satisfaction of needs, schedule, and travel time along with their social-economic stage information. First, they were made to understand that the activities are classified into six main categories that represent the hierarchical needs based on Maslow. The categories are physical care, homemaking, family care, work-oriented, pleasure and socialization. Next, questions pertaining to the respondent's long-term priority of needs, corresponding needs ranking, and the level of satisfaction for each of the needs were asked. After priority ranking, the next step was to obtain their diary-based activities. Then respondents were asked to imagine that their one-way commuting time is reduced to half an hour (or one hour, two-way). Finally and most importantly, they were asked how they would use or accommodate the hypothetical time saving into their schedule and how much they are willing to pay for this benefit. The activity extension that they preferred were recorded and classified accordingly.

2.2 Data Compilation and Analysis

The result of the survey is explained in this section. Figure 2 shows that the highest priority rank among samples are the long term priority need for family care (35.0%), followed by physical care (30.1%), and then pleasure (17.3%), working (12.0%), homemaking (3.0%) and lastly socialization (2.6%). For the analysis on level of satisfaction of needs in their time allocation, the results are given in Figures 3A&B. The respondents were grouped according to their top need (according to their priority ranking of needs) and the bars show the time consumption proportion for each group. (No individual ranked homemaking as their top need and thus homemaking does not appear in the figures.)

Observing Figure 3 A&B as indicated by arrows, it can be seen that an individual's priority of a certain need is revealed by the tendency of having higher time allocation for that particular need. He revealed it in his time allocation showing that the top priority need allocation is relatively higher than other type of individual's. Thus, the priority of individuals seems to influence on how they arrange their time allocation.

Figures 4A&B show the example of level of need satisfaction. Respondents are grouped by individual rank. For example, for the satisfaction level of Family Care (Figure 4A) there are 78 individuals who prioritize "family care" as the first rank, and less than 25% of them are

dissatisfied with the time availability. Following the same analysis for all types of needs, results revealed that for "Work", "Family Care", and "Socialization", it seems only around 25% are dissatisfied, while for the need on "Pleasure" and "Physical Care", the dissatisfaction is relatively higher at more than 25%, and 50%, respectively.

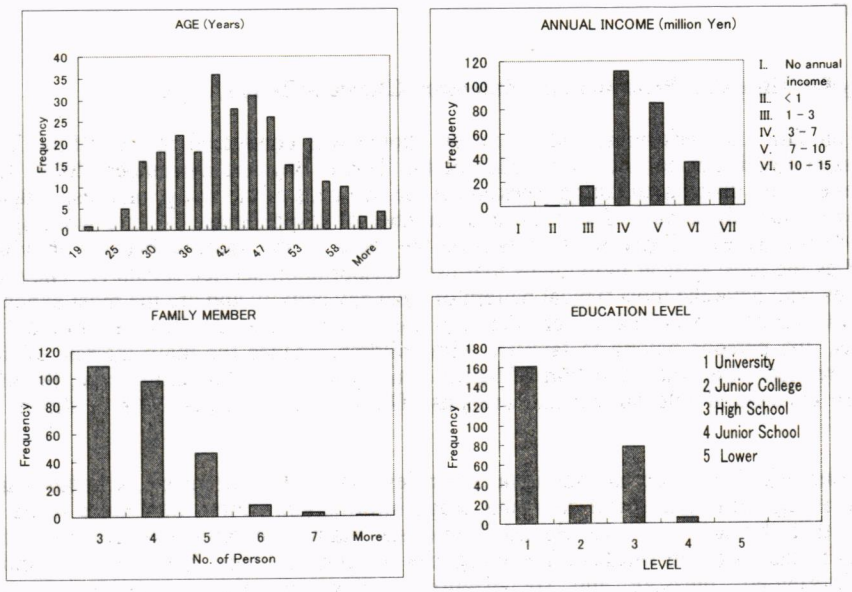

Figure 1. Respondent Data

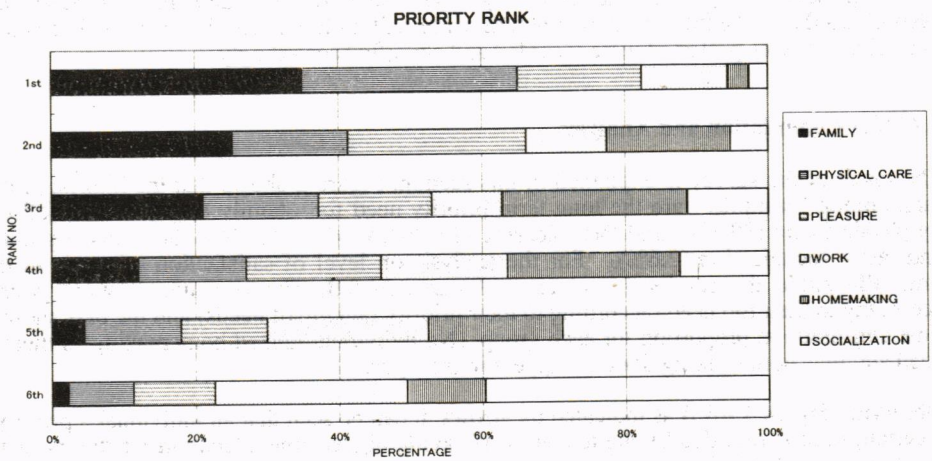

Figure 2. The Rank of Priority for Each Need

The compilation of data that corresponds to the question on what type of activity individuals will most likely engage in or extend given one hour extra time, is shown in Figure 5. The figure shows that around 33.4% of the respondents chose to engage in or extend family care

activities with the extra time, while 25.5% chose pleasure, and another 22.8% for physical care, reflecting the need of individual well being.

Willingness-to-pay (WTP), the measure that could show how much the individuals value the time saving for doing activity is shown in Figure 6. In terms of proportion of income, on the average, respondents are willing to pay for about 30% of their hourly income to buy a service of time saving. In actual currency, WTP is around 890 yen per minute. WTP in currency is broken down for each type of activity, and shown in Figure 7.

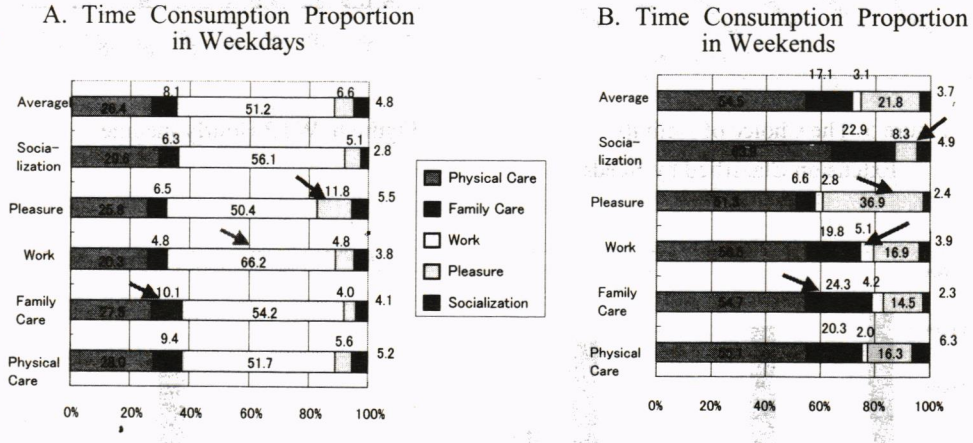

Figure 3. Proportion of Time Consumption for Each Need Grouped By Top Priority

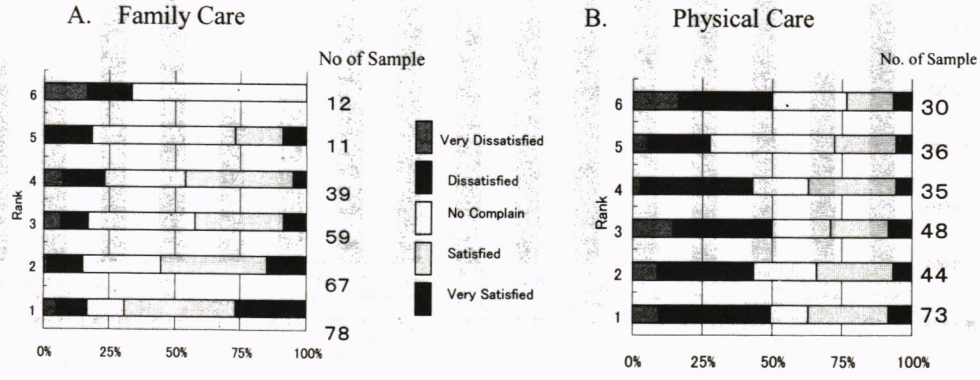

Figure 4. Level of Satisfaction of Needs

In Figure 7 (WTP-Income ratio for type of activity), it is observed that the most prominent value of activities are: the activity of going to cultural events (both in terms of proportion to income and monetary value), followed by going to amusement/ theme park activity, and going to hot spring/relaxation. Most of these activities were done with family. These seem to reflect the combined need for family care, pleasure and physical care. The non-work activity related to work societies is also significantly high. The value of time for work for the individuals who prioritize work and works on Saturdays (and also has the intention to extend it) is not significantly high.

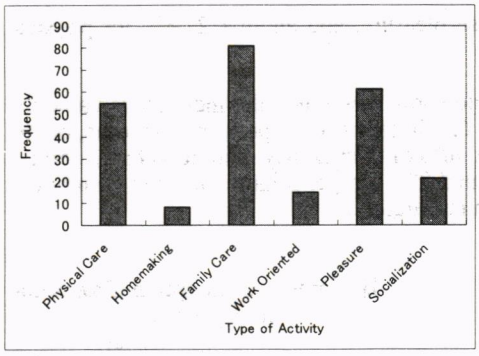

Figure 5. The Choice of Activity Extension Classified by Needs

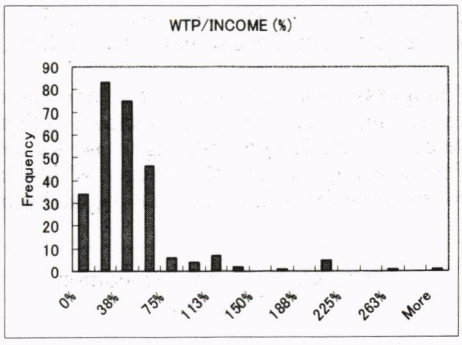

Figure 6. WTP/Hourly Income

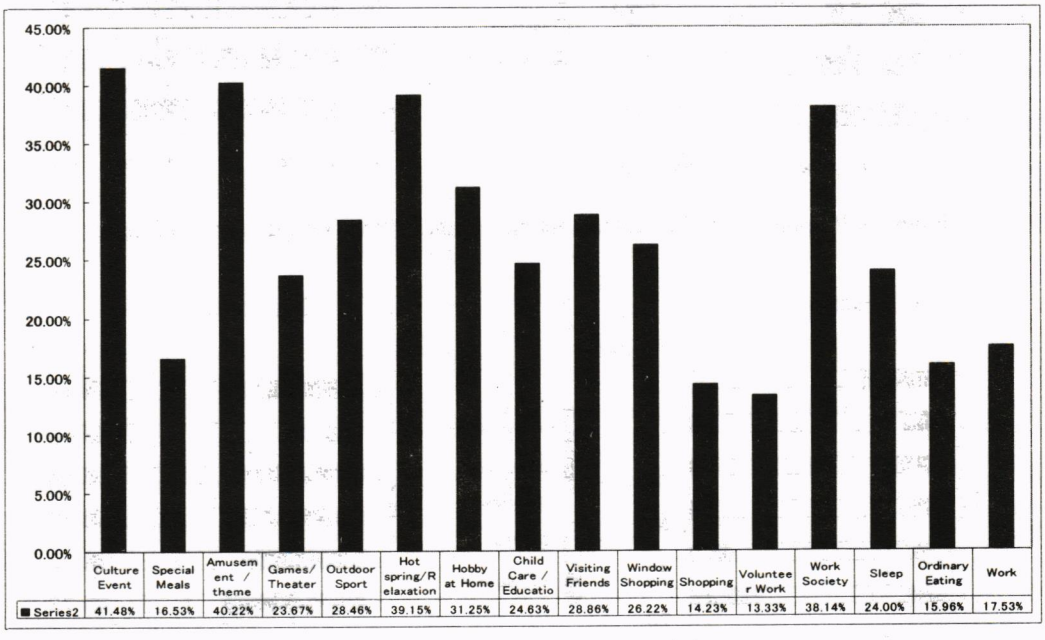

Figure 7. WTP/ Hourly Income for Type of Activity

2.3 Obtaining Parameters of Individual Attributes Using Multivariate Analysis

In the survey, ranking data of priority needs was obtained. In analyzing individual attributes that can influence priority, a multivariate analysis was applied, and the result of the analysis is given in Table 1. The purpose of this analysis is to come up with the set of attributes that could most significantly explain ranking of need priorities. However this method, with its property, is considered not quite satisfactory in describing the value of the needs and its correlation to the variables. Hopefully this can be improved and refined in later analyses to obtain the parameters for the proposed model of utility of activity.

Table 1. Attributes and Parameters for Ranking of Priority of Needs

Item	Category	Needs					
		Physical Care	Home-making	Family Care	Work	Pleasure	Socia-lization
Sleep (Weekdays)	Satisfied	0.29	-0.37	-0.41	0.37	0.03	0.09
Overtime (Weekdays)	Taken	-0.01	0.26	-0.11	0.14	-0.39	0.10
Homemaking (Weekdays)	Satisfied	0.30	0.77	-0.24	-0.67	0.08	-0.24
Office Socialization (Weekdays)	Satisfied	0.08	0.25	0.22	0.12	-0.50	-0.19
Local Socialization (Weekdays)	Satisfied	0.16	-0.29	-0.21	0.20	-0.35	0.51
Breakfast with Family (Weekdays)	Satisfied	0.16	0.16	-0.26	0.01	-0.09	0.05
Dinner with Family (Weekday)	Satisfied	-0.27	-0.22	-0.07	0.45	0.13	-0.03
Family Entertainment (Weekday)	Satisfied	-0.40	0.10	0.27	0.24	-0.08	-0.12
Personal Entertainment(Weekday)	Satisfied	-0.33	-0.30	0.19	0.29	-0.03	0.15
Hobby in House (Weekdays)	Satisfied	0.44	0.17	0.53	-0.04	-0.56	-0.52
Watch TV/Radio(Weekdays)	Satisfied	-0.04	-0.01	0.01	-0.87	0.83	0.08
Holiday?	Holiday	0.13	-0.42	0.22	-0.05	0.16	-0.04
Age	Under 30's	-0.14	0.18	0.36	0.42	-0.41	-0.41
	30's	-0.05	-0.12	-0.19	0.39	-0.25	0.21
	40's	0.14	0.31	-0.17	-0.41	0.24	-0.11
	Over 40's	0.09	-0.29	0.29	-0.87	0.73	0.06
Sex	Male	1.28	0.19	-0.25	-0.70	-0.15	-0.37
Status	Married	-0.43	0.31	-1.03	0.23	0.32	0.62
Driving Frequency	Less than 4times /mnth	-0.03	-0.16	-0.10	0.23	0.04	0.01
	1,2 times/week	0.01	-0.21	-0.01	0.22	0.04	-0.06
	3,4 times/week	-0.07	0.12	0.49	-0.06	-0.60	0.07
	Everyday	0.01	0.21	-0.06	-0.24	0.05	0.04
Occupation	Private Company	0.02	-0.03	-0.05	0.00	-0.02	0.09
	Public Company	-0.23	-0.22	0.23	0.57	0.08	-0.42
	Self Employed	0.22	0.71	0.17	-1.05	0.08	-0.19
Annual Income	Under 3 million Yen	1.02	0.13	-0.64	-0.01	0.73	-1.22
	3-7 million Yen	0.03	-0.09	0.19	-0.16	-0.01	0.03
	7-10 million Yen	0.03	0.22	-0.37	0.18	-0.21	0.15
	10-15 million Yen	-1.02	-0.50	0.65	0.44	0.42	0.01
	Over 15million Yen	0.02	0.31	-0.03	-0.37	-0.53	0.60
Education	University	-0.01	0.08	0.00	-0.07	0.02	-0.02
	Junior University	-0.41	0.25	-0.06	0.00	-0.23	0.46
	Highschool	0.16	-0.25	0.01	0.15	0.03	-0.10
Holiday system	Once a week	0.34	-0.96	0.07	0.53	-0.06	0.11
	Once a week plus 1~3	0.67	0.05	-0.16	-0.39	-0.10	-0.08
	Twice a week	-0.18	0.13	0.02	-0.01	0.03	0.01
	Other	0.74	-1.02	0.03	0.39	-0.13	-0.09
1~6 Child	Exist	-0.27	-0.06	-0.39	-0.16	0.63	0.24
7~12 Child	Exist	0.44	-0.39	-0.02	0.11	-0.53	0.40
13~15 Child	Exist	0.12	-0.54	0.33	0.19	0.10	-0.20
16~18 Child	Exist	0.08	0.62	0.33	-0.78	-0.73	0.49
Constant		4.20	4.25	1.25	3.51	2.78	4.99
Mutiple Correlation Coefficient		0.42	0.50	0.60	0.51	0.50	0.53

3. THEORETICAL FRAMEWORK

3.1 General

Assuming that an individual will maximize the fulfillment of needs with time as their resource, then the referred theory in this sense is microeconomic demand and consumer theory. The consumer has needs to be fulfilled through activities. Time here will be analogous to money or income, having a constraint and budget, although it is not exactly like money, because it can't be stored and used at a latter date. The commodities or products here will be the needs that will drive people to do activities. The needs are defined as in Table 1, i.e., physical care, homemaking/comfort, family care, socialization, and pleasure, based on Maslow's psychological theory applied to a daily context. The activity, for example, is eating breakfast alone at home, or eating dinner with wife at home or restaurant. Each activity has its own level of utility and could be higher or lower than another.

3.2 Utility-of-Activity Model

The researches of Kraan (1995), Kitamura (1999, 1997), Kitamura and Supernak (1997) that have modeled the utility of activity as a function of time are very useful and served as

inspiration for this research. The focus of this research is to work in more detail on the coefficients of the utility function. Individuals do the activities driven by the motivation of fulfilling needs, as explained by Maslow. This main assumption will be the basic idea in formulating the utility function.

Table 2. Explanation of Needs

NO	TYPE OF NEEDS TERMS	MOTIVATIONAL MASLOW NEEDS TERMS
1	Physical Care	Physiological
2	Comfort/Homemaking	Safety and Security
3	Family Care	Love and Belongingness
4	Socialization	Self Esteem by Others
5	Work Performing	Self Sufficiency, Meaningfulness
6	Pleasure	Truth, Beauty, Perfection

The functional form of utility of one activity i is:

$$U_i = U_i(\gamma_i, t_i) \quad \text{.....(1)}$$

where γ is a positive coefficient of activity i, and t is time allocated for activity i. It had been explained that in doing an activity there is a purpose to fulfill needs. For instance, if there is a need j to be fulfilled in activity i, then coefficient γ can be explained in more detail as:

$$\gamma_i = \gamma_i(\alpha_j, \beta_j) = \alpha_j \beta_{ij} \quad \text{.....(2)}$$

where α_j is a vector of values that show individual lifestyle priority toward needs j, while β_{ij} is a parameter. It is assumed that α_j is a variable and not a function of time allocation and could be defined as :

$$\alpha_j = \alpha_j(\omega, X) = \omega X \quad \text{.....(3)}$$

where ω is vector of parameters and X is a vector of individual attributes that show conditions, and situation of individuals, for example income, number of children, and life cycle stage as illustrated in Table 1.

Nevertheless, it needs to be considered that individuals engage in one activity to fulfill more than one need. For example, the activity of eating with family in a restaurant contains two elements of need, the "physical need" of eating and the "family care" need as a result of being together. Thus, to describe the condition where an activity fulfills j to k needs, the γ is defined as:

$$\gamma_i = \sum_j^k \alpha_j \beta_{ij} = \sum_j \sum_k \omega_{ik} X_k \beta_{ij} \quad \text{.....(4)}$$

Finally, with the assumption that the activity is the medium to fulfill needs, the utility of activity is formulated as follows:

$$U_i = U_i(\gamma_i, t_i, \theta_i) = \gamma_i t_i^{\theta_i} \quad \text{.....(5)}$$

with $t_i > 0$ otherwise $U_i = 0$

where θ_i = parameter that determines the shape of the utility curve.

In the effort of validating the utility model and obtaining the parameters of the model, two approaches or methods are proposed in this research. These two approaches are utility maximization in time allocation and the choice of activity time extension. Both of these approaches are used to obtain estimates of the parameters.

3.2.1 Utility Maximization in Time Allocation Method

The first method is using maximization in time allocation. The sum of utilities for activities i to R will maximize the total utility in the time span, for example in this case, one day or one week, and is formulated as follows:

$$\max \quad U_{total} = \max \quad \sum_{i}^{R} U_i \qquad \text{.....(6)}$$

s.t.

$$T = \sum_i t_i \qquad \text{the total available time for doing activities} \qquad \text{.....(7)}$$

$$C = \sum_i p_i t_i \qquad \text{the total budget allocation for pursuing activity} \qquad \text{.....(8)}$$

where

t_i = time of each activity

p_i = price of activity/service time.

Using Lagrange method, the following equations are obtained:

$$L = \sum_i \gamma_i t_i^{\theta_i} + \lambda_T (T - \sum t_i) + \lambda_C (C - \sum_i p_i t_i)$$

$$L = \sum_i U_i - \lambda_T \left(\sum_i t_i - T \right) - \lambda_C \left(\sum p_i t_i - C \right)$$

$$\rightarrow L = \sum_i \gamma_i t_i^{\theta_i} - \lambda_T \sum_i t_i + \lambda_T T - \lambda_C \sum p_i t_i + \lambda_C C$$

$$\frac{\partial L}{\partial t_i} = \gamma_i \theta_i t_i^{\theta_i - 1} - \lambda_T - \lambda_C p_i = 0$$

$$\frac{\partial L}{\partial t_i} = 0, \frac{\partial L}{\partial \lambda_T} = 0, \frac{\partial L}{\partial \lambda_C} = 0 \qquad \text{.....(9)}$$

Lagrange multiplier is the derivative of the objective function on the restriction functions:

$$\lambda_T = \frac{\partial U}{\partial T}, \quad \lambda_C = \frac{\partial U}{\partial C} \quad \text{thus} \quad \lambda_C = \frac{\partial T}{\partial C} \lambda_T \qquad \text{.....(10)}$$

and using (9) and (10) we obtain,

$$\lambda_T = \frac{\gamma_i \theta_i t_i^{\theta_i - 1}}{1 + \frac{\partial T}{\partial C} p_i} \qquad \text{.....(11)}$$

because λ_T is fixed implying that the marginal utility of every activity is considered equal, thus:

$$\frac{\gamma_1\theta_1 t_1^{\theta_1-1}}{1+\frac{\partial T}{\partial C}p_1} = \frac{\gamma_2\theta_2 t_2^{\theta_2-1}}{1+\frac{\partial T}{\partial C}p_2} = \ldots\ldots = \frac{\gamma_i\theta_i t_i^{\theta_i-1}}{1+\frac{\partial T}{\partial C}p_i} \quad \ldots\ldots(12)$$

In order to come up with a solution we need one more equation, that is :

$$\sum_i \gamma_i = A \qquad \text{which is set as an arbitrary constant} \quad \ldots\ldots(13)$$

Using equations (12) and (13) given θ_i, t_i, p_i and $\partial T/\partial C$, λ_T and each γ_i (although still using the arbitrary constant A) can be obtained.

3.2.2 Time Extension Choice Method using Marginal Utility

The second approach is to obtain a parameter using a choice model for activity extension. From the first method we can model the time allocation, with consideration that all the marginal utilities are equal. This latter method will be used for verification and refinement of the parameter estimation.

To explain this, it is assumed that there is a marginality to maximize total utility U taking advantage of ΔT as time saved, represented by:

$$\max U' \big| \Delta T \quad \ldots\ldots(14)$$

Then for a type of activity (i) that is chosen to be extended by Δt_i, the utility will be:

$$U_i' = U_i + \frac{\partial U_i}{\partial t_i}\Delta t_i + \varepsilon_i \qquad = \gamma_i(t_i^{\theta_i} + \theta_i t_i^{\theta_i-1}\Delta t_i) + \varepsilon_i \quad \ldots\ldots(15)$$

with ΔU_i for each activity calculated as:

$$\begin{aligned}\Delta U_i &= \gamma_i(\theta_i t_i^{\theta_i-1}\Delta t_i + \mu_i) + \eta_i \\ &= \gamma_i\theta_i t_i^{\theta_i-1}\Delta t_i \quad + \gamma_i\mu_i + \eta_i \\ &= \gamma_i\theta_i t_i^{\theta_i-1}\Delta t_i \qquad\quad + \varepsilon_i' \\ &= \Delta V_i + \varepsilon_i'\end{aligned}$$

Hence:

$$\Delta V_i = \gamma_i\theta_i t_i^{\theta_i-1}\Delta t_i \quad \ldots\ldots(16)$$

where $\varepsilon_i, \mu_i, \eta_i, \varepsilon_i'$ = error terms caused by social, culture and other unobserved heterogeneities.

To which activity the Δt will be reallocated to, is presumed the extension of activity that will give the highest change of ΔU. Then the probability that a type of activity (i) is chosen to be extended by individual n is:

$$P_{in} = \Pr(\Delta U_{in} \geq \Delta U_{kn},\ \forall j \in C_n, k \neq i)$$

$$P(i|\Delta T) = \Pr(\Delta U_i \geq \Delta U_j) = \Pr(\Delta V_i + \varepsilon_i' \leq \Delta V_j + \varepsilon_j') = \Pr(\varepsilon_j' - \varepsilon_i' \leq \Delta V_i - \Delta V_j) \quad \text{.....(17)}$$

If the errors are normally distributed and correlated because of interdependency between activity or needs then the use of multinomial probit model is proposed.

$$P_i = \int_{\varepsilon_1=-\infty}^{\varepsilon_i+\Delta V_i-\Delta V_1} \cdots\cdots \int_{\varepsilon_i=-\infty}^{\infty} \cdots\cdots \int_{\varepsilon_R=-\infty}^{\varepsilon_i+\Delta V_i-\Delta V_R} \phi(\varepsilon) d\varepsilon_R \cdots \varepsilon_1 \quad \text{.....(18)}$$

$$\phi(\varepsilon) = (2\pi)^{\frac{-R}{2}} |\Sigma|^{\frac{-1}{2}} \exp(\frac{-1}{2} \varepsilon \Sigma^{-1} \varepsilon^T)$$

with R as the number of activities or alternatives , $\sum$ is the covariance matrix error.

Applying this formula and using the maximum likelihood method it is expected that each γ_i and θ_i can be obtained.

3.2.3 The Relationship between Time Allocation Model and Activity Choice Model

These two models will be used for estimating the parameters of the utility model by comparing both of them and refining the result. The first method is based on the assumption of that marginal utility for each activity is equal and can be used to calculate time allocation, but the parameters obtained are still arbitrary. The second method is quite different with the assumption that the marginal utility is not necessarily equal and is the reason for making choice extension. Both of the methods are supportive in finding the parameters. The main idea is that time saving will be allocated to the type of activity according to the probability of the activity being extended as a result of having the highest marginal utility. The formulation of new time allocation is written as:

$$T + \Delta T = \sum_i t_i + \Delta TP_i \quad \text{and then, ...(19)}$$

$$\Delta T = \sum_i \Delta t_i = \sum_i \Delta TP_i \quad \text{.....(20)}$$

Using the equation (5) and (11) we get:

$$V_i = \sum_i \left\{ \frac{\lambda_T \left(1 + \frac{\partial T}{\partial C} p_i\right) t_i}{\theta_i} \right\} \quad \text{.....(21)}$$

The new time allocation with the additional time saving will reach another state of equal marginal utility with the equation:

$$\lambda'_T = \frac{\gamma_i \theta_i (t_i + \Delta TP_i)^{\theta_i - 1}}{1 + \frac{\partial T}{\partial C} p_i} \quad \text{.....(22)}$$

The change in the utility of activity will thus be:

$$V_i + \Delta V_i = \left\{ \frac{\lambda_T \left(1 + \frac{\partial T}{\partial C} p_i\right)(t_i + \Delta T p_i)}{\theta_i} \right\} = \frac{\gamma_i \theta_i (t_i + \Delta T p_i)^{\theta_i - 1}}{\left(1 + \frac{\partial T}{\partial C} p_i\right)} \times \frac{\left(1 + \frac{\partial T}{\partial C} p_i\right)(t_i + \Delta T p_i)}{\theta_i}$$

$$= \gamma_i (t_i + \Delta TP_i)^{\theta_i}$$

Hence,

$$\Delta V_i = \gamma_i (t_i + \Delta TP_i)^{\theta_i} - \gamma_i t_i^{\theta_i} \quad \text{.....(23)}$$

Referring to the equation from the Time Allocation Model (10), (11) and Choice Model (20), (23), the basic intention is to have:

$$\lambda_T = \frac{\partial V_i}{\partial t_i} \cong \frac{\Delta V_i}{\Delta t_i} \quad \text{.....(24)}$$

The right- and left-hand side terms can be checked for closeness of value. Otherwise, iterations will be done changing the value of γ_i and the arbitrary constant A of the equation (13) for each iteration until the difference between two values narrows down. Using this method it is possible to estimate each γ_i.

4. THE FEATURE OF THE MODEL

Having the attributes of the individual and the parameters, the model intends to predict the time use for each individual's type of activity and the most possible activity time extension. This model is expected to feature an understanding of, firstly, the priority of each need as a life style of individual, and also the intension of which activity time they are going to extend. The results can then be used to predict the possible time-saving utilization of individuals.

4.1 The Expected Result

In order to verify the validity of the model, the basic characteristics of the model are examined. The change in individual time allocation obtained from the model is calibrated to the actual intended change by changing each of the parameters. As an illustration, several cases that consider three needs and three activities were performed. Table 3 represents the changed and assumed parameter values. In this case, α_j is the importance level of need j, and θ_i is the efficiency of activity i to fulfill need j.

Table.3. Assumption of Parameters

Activity	p_i	θ_i
Rest in home (i =1)	100	0.20
Hobby in home (i =2)	200	0.25
Go out with family (i =3)	400	0.30

$$\text{(Matrix Form)}\quad \beta = \begin{pmatrix} 10 & 1 & 1 \\ 1 & 10 & 1 \\ 1 & 1 & 10 \end{pmatrix} \quad \alpha = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} \text{ (Initial)}$$

Initialization was set to have total time T =100 and total disposable income C = 20.000. The changing parameters would be α, θ_i, and T.

Case 1 : α_3 changes

Increasing α_3 implies increasing importance of family care needs. For instance, the changing of life stage, and the number and increasing age of children can influence the level of importance of family care. This will result in time allocation change as shown in Figure 8. Based on the calculation of the model, we can see that the time for family activity out of home increases while the time for other activities decreases. The sudden decrease of "rest at home" occurs around α_3 =1.125. To compare and illustrate with real condition, Figure 9 shows average time allocation of respondents from the Tokyo survey. People who worked five days a week were divided into two types by satisfaction/dissatisfaction of the family care needs on weekdays. Based on this figure, we can see more clearly the difference between those two types, that is, the time allocation proportion of "go out with family" of the "not sufficient" group is more than the proportion of the "sufficient" one. This confirms the result of the model.

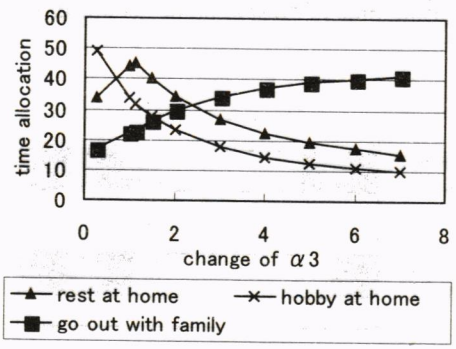

Figure 8 α_3 vs Time Allocation

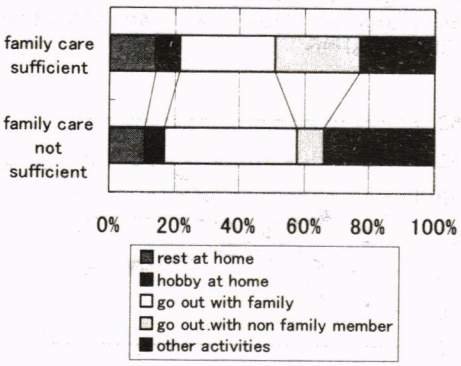

Figure 9 . Time Allocation for Types

Case 2 : θ_3 changes

θ_i is the parameter related to whether individuals do the activities efficiently or not. If θ_i is large, people can satisfy the needs efficiently by doing activity *i*. From the analysis in the changing θ_3, there exist three stages of change. Firstly, for θ_3 values up to 0.15 , as shown in Figure 10, the time allocation of "going out with family" increases while the others decrease. In this stage, total cost did not yet reach total budget. In the second stage, when the total budget constraint is reached, the time allocation of "rest at home" become increasing. In the third stage, in which total time is not used completely, the time for "rest at home" starts to decrease again. Observing actual data (Figure 11), the time allocation of "go out with family" and "rest at home" increased and "hobby at home" decreased, which matches the second stage in the analysis.

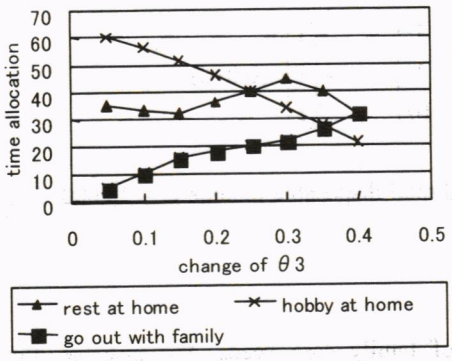

Figure 10. θ_3 vs Time Allocation

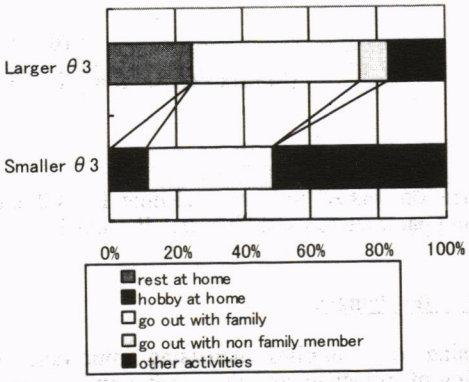

Figure 11 . Time Allocation for θ_3

Case 3 : Total Time Changes

The change in total time T reflects expansion of available time, though still without change of the total budget. Figure 12 shows time allocation variation with the change in total time T. For this case the time of two activities were expanded with relatively lesser cost. For T values up to 70, the total cost did not reach the budget constraint. After this point, the budget constraint has been reached and the proportion of time allocation of "go out with family " starts to decrease. Again comparing with real conditions (Figure 13), it is seen that the tendency of decreasing time of "go out with family" and increasing time of "rest at home" confirms the result of the analysis.

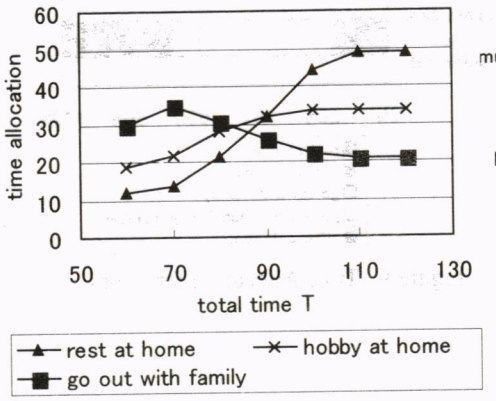

Figure 12. T vs Time Allocation

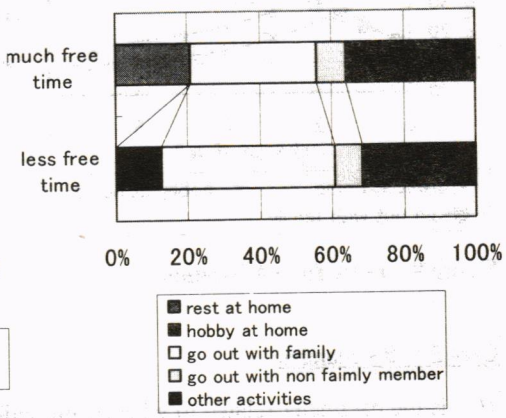

Figure 13 . Time Allocation for $\triangle T$

4.2 Discussion

The parameters and values in the examples above are largely based on assumption. The parameters that represent the behavior of the individual need to be estimated. Given the representative parameters and individual attributes, it is thus expected that the model could predict how individuals having certain characteristic would allocate time. The change of time

allocation as a result of time saving can also be calculated. In addition to individuals, groups can also be analyzed. For example, a community can be grouped into several types of attributes such as sex, income and life cycle, and we could estimate the possible time allocation for particular groups types.

5. CONCLUSION AND FURTHER RESEARCH

According to the survey conducted most of the respondents in Tokyo have higher need for family care, physical care and pleasure in the weekend as shown by the way they allocate time. These needs are to be fulfilled within limited time on weekends and as a consequence, the time for doing this activity is valuable for them. Considering the benefit of time saving, the extra time is not necessarily allocated for production activity since this depends on the needs and types of the individual.

Regarding the proposed model, the model is able to relate the characteristic of individuals or population with activities they will do given extra time. The variable α that represent individual level of importance for each need will determine time allocation.

In relation with WTP for time saving for each type of activity or need, it is regarded that the higher the level of need is, the higher the WTP. As seen from the data, WTP for travel time saving for Culture Event, and Going to Amusement Park with family are prominently high because the needs for "family care" and "pleasure" are fulfilled. So the model could explain that value of time for a non-productive activity such family activity, physical care and pleasure could be much higher when it is highly demanded or needed.

Furthermore, from this research, it is possible to understand the behavior of an individual or community toward needs. It is also possible to understand what kind of activity individuals may feel lacking based on their stated intentions and preferences. Time saving as an impact of a project can be explained by this model, and treat it as a social welfare benefit. It could be noted that the economic benefit may come indirectly from the increase in work efficiency or effectiveness as a result of properly fulfilling other needs such as family care and pleasure.

Further effort is still required to improve the model. The estimation of parameters involved must still be verified. Some assumptions, considerations, and definition of errors need to be dealt with. The model still need continuing improvement and development, but examples shown in this paper has shed some directions on the features that this model will have.

REFERENCES

a) Books and Books Chapter

Ben Akiva, M and Lerman S.R. (1993) **Discrete Choice Analysis: Theory and Application to Travel Demand**, The MIT Press.

Chapin Jr, F. (1974) **Human Activity Pattern in The City : Things People Do in Time and Space**, John Wiley and Sons.

Maslow, Abraham H. (1970) **Motivation and Personality** , New York : Harper & Row ,
NHK (1995) **The Japanese Daily Life Activity Schedule**, NHK, (in Japanese),

Jones, Dix, Clarke, Heggie (1992) **Understanding Travel Behaviour**, Oxford Studies in Transport, Gower

b) Journal Paper

Becker G.S. (1965) A Theory of The Allocation of Time, **The Economic Journal**, pp 493-517.

Bhat, Chandra R, Koppelman, F.S. (1999) A Restrospective and Prospective Survey of Time-use Research, **Transportation Volume** 26 No 2. May, pp 119-139

Bruzelius, Nils. (1979) Measuring the Value of Travel Time Savings From Demand Function, Chapter 15, **Behavioural Travel Modeling,** edited by Hensher, D. and Stopher, P.R., pp 334-354.

DeSerpa (1971) A Theory of The Economics of Time, **The Economic Journal**, pp 828-845.

Ettema D, Borgers A, Timmermans H. (1993) Simulation Model of Activity Scheduling Behavior, **Transportation Research Record 1413**, pp 1-11.

Garling T, Ettema D. *et al*, (1995)Towards A Theory of Intention-Behavior Relationship With Implication for The Prediction of Travel Behavior, **7th WCTR Sydney Australia, Topic 15. Travel and Choice Modelling, Volume 1**, pp 231-240.

Hagerstrand, T. (1970), What About People in Regional Science, **Papers of The Regional Science Association**, Vol. XXIV, pp 7-21

Hensher, David A. (1997) Behavioral Value of Travel Time Savings in Personal and Commercial Automobile Travel, **The Full Costs and Benefits of Transportation** . Springer, pp 245-279.

Kitamura R., Supernak J. (1997) Temporal Utility Profiles of Activities and Travel : Some Empirical Evidence, **Understanding Travel Behavior in an Era of Change** (P.R. Stopher and M Lee-Goselin eds) Pergamon Press (forthcoming) , pp 339-349.

Kitamura R., Yamamoto T. (1999) An Analysis of Time Allocation to In-Home and Out-of-Home Discretionary Activities Across Working Days and Non-Working Days, **Transportation 26**, Kluwer Academic Publisher, pp 211-230.

Kitamura R., van der Hoorn T,and van Wijk F (1997) A Comparative Analysis of Daily Time Use and The Development of An Activity-Based Traveler Benefit Measure, **Activity Based Approaches to Travel Analysis**, Pergamon, pp 171-187.

Kraan, Mariette (1995) Modeling Activity Patterns with Respect to Limited Time and Money Budget, **Topic 15, Travel Choice and Demand Modeling, 7th WCTR Sydney Australia. Vol 1. Travel Behavior**, pp 151-163.

Pas, E.I., and Harvey, A.S., Time Use Research and Travel Demand Analysis and Modelling, **Understanding Travel Behavior in an Era of Change** (P.R. Stopher and M Lee-Goselin eds) Pergamon Press (forthcoming) , pp 315-333.

Pearce, Philip L. (1982) **The Social Psychology of Tourist Behaviour, International Series in Experimental Social Psychology, Volume 3**, Pergamon Press, pp 48-67.

c) **Papers presented to conferences**

Prasetyo, I., Tamura, S. and Yai, T. (2000) Travel Time Saving Benefit Based on Commuter's Perception (Jakarta, Indonesia Case Study). **Proceedings of The Third Regional Symposium on Infrastructure Development in Civil Engineering,** Tokyo Institute of Technology, Japan, pp 429-438