Copula-based Modeling of Tourists' Multi-Destination Visit and Resource Allocation Behavior†

Junyi ZHANG[1] , Hui ZHANG[2], and Lingling WU[3]

[1] Member of JSCE, Professor, Graduate School for International Development and Cooperation, Hiroshima University (1-5-1 Kagamiyama, Higashi-Hiroshima, 739-8529, Japan)
E-mail: zjy@hiroshima-u.ac.jp
[2] Former Master Course Student, Graduate School for International Development and Cooperation, Hiroshima University (1-5-1 Kagamiyama, Higashi-Hiroshima, 739-8529, Japan)
E-mail: hzhang@126.com
[3]Member of JSCE, Research Fellow, Institution for Transport Policy Studies, Japan
(3-18-19 Toranomon,Minato-ku,Tokyo,105-0001,Japan)
E-mail: wuling1017@gmail.com

Focusing on tourist behavior, this paper develops a nested time use and expenditure behavior model in the context of multi-destination visit, where a tourist visits one or more destinations. In this case, tourists' decisions include, 1) whether to visit a destination or not (destination visit decision), and in case of visiting a destination, 2) how long to stay there (activity time decision), 3) whether to spend any money there (expenditure decision), and in case of spending any money, 4) how much of money to spend there (expenditure level decision). To accommodate the above decision-making mechanism with two discrete and two continuous dependent variables, a nested Tobit modeling technique is first integrated with a multi-linear utility-maximizing time use and expenditure behavior model, and then a pair copula is applied to represent the correlated error structure of the above four dependent variables. Pair copula is a function that can combine different bivariate copulas to represent a joint multivariate distribution, where variables are sequentially incorporated into conditioning sets with a nested tree structure. As a case study, the developed model is estimated by comparing three types of canonical vine copulas: Gaussian, FGM and Frank copulas. First, the model effectiveness is confirmed by using a questionnaire data collected in the Tottori Prefecture of Japan in 2007. Second, it is revealed that the Frank canonical vine pair copula model is superior to other models. Third, it is found that the value of activity time varies considerably with tourists' origins. Finally, influential factors to time use and expenditure behavior are examined.

Key Words : *tourist behavior, time use, expenditure, multi-destination, multi-linear utility, pair copula, nested Tobit modeling*

1. INTRODUCTION

This study deals with tourists' time use and expenditure behaviors, which have been analyzed in the fields of transportation and tourism studies, etc (e.g., Pearce, 1988; Becken and Gnoth, 2004; King and Woodside, 2001; Fujiwara and Zhang, 2005; Jang and Ham, 2009; LaMondia, 2010). Analyses of such tourist behavior could provide useful insights into transportation policies to support tourist destination management, transportation planning, tourism marketing and so on. Time use is an important indicator to measure people's quality of life (e.g., Pentland et al., 1999; Phillips, 2006) and at the same time, it is linked with energy consumption and the resulting environmental loads caused by tourism activities. It is expected that time use is influenced by tourism services (including the relevant transportation services) and consequently it can be used to measure the quality of tourism services. Expenditure spent by tourists is certainly a direct indicator to measure the effects of tourism policies on economic development. Thus, properly understanding tourists' time use and expenditure behaviors is important for policy decision makers and has its own practical rationality.

Behaviorally, within a same destination, decisions on time use and expenditure might be interrelated (intra-destination interactions), while similar interrelationships might be observed across destinations (inter-destination interactions). Needless to say, decision on whether to visit a destination or not is the basis for other successive decisions. However, careful review suggests that little has been done to deal with the above behavioral phenomenon, except the following two studies conducted by the authors. The first study was done by Zhang et al. (2009), who represented how a tourist allocates his/her limited time and monetary budgets to various tourism activities, given that destinations are visited. The second study by Zhang et al. (2012) is an extension of the first study by explicitly representing activity participation based on the concept of self-selection. Both of the studies assume that a tourist maximizes his/her utility derived from time and monetary consumption by using a multi-linear utility function. Using the multi-linear utility function, behavioral relationships between time use and expenditure can be measured together with the relative importance of each activity during decision-making processes. The distinction between the first and second studies is that: the first study represents the influence of behavioral context-sensitivity specified by introducing attribute-based inter-alternative similarities and spatial closeness between alternatives, whereas the second allows for whether to take part in activities or not (i.e., activity participation behavior) in the modeling process. The shortcoming of the second study is that zero consumption of expenditure was treated as a part of continuous consumption.

The purpose of this study is to propose a new tourist resource allocation model that can simultaneously resolve the above behavioral issues. In this study, time use and expenditure within a single trip are treated at the destination level, given that a tourist already decided to visit one or more destinations. The targeted decision variables include, 1) whether to visit a destination or not (note that the first destination must be visited), and in case of visiting any destination, 2) how long to stay at destination, 3) whether to spend any money at destination, and 4) in case of spending any money, how much to spend. The modeling task is how to jointly represent the above behavioral decisions. Unfortunately, to date, no study has been done in line with such consideration at least in the context of tourist behavior analysis.

As an initial attempt, this study develops a nested tourist time use and expenditure behavior model with multi-destination visit by integrating the above multi-linear utility modeling framework and the concept of pair copula. Pair-copula has a nested structure to accommodate more general dependence structure in joint distributions, where variables are sequentially incorporated into conditioning sets. An empirical analysis is further conducted to confirm the effectiveness of the developed model by using a tourist questionnaire data collected in Tottori Prefecture in 2007.

The rest of this paper is organized as follows. Pair copulas are first briefly described in Section 2 and tourists' time use and expenditure behavior model without zero consumption are then illustrated in Section 3. After that, a time use and expenditure behavior model with zero consumption based on a pair copula is developed in Section 4. Section 5 describes the data used in this study, and Section 6 discusses the model estimation results. Finally, Section 7 summarizes the findings together with a discussion about future research issues.

2. PAIR COPULA

2.1 Basic concepts of copula

Copula is a function that can combine margins to represent a joint multivariate distribution with the help of dependence parameter(s). Given an arbitrary *n*-dimensional joint distribution function $F(x_1,\cdots,x_n)$, which margin is $F_i(x_i)$, it can be represented as an *n*-dimensional copula function *C* (a function of $F_i(x_i)$) with dependence parameter(s) (θ), as shown below.

$$F(x_1,\cdots,x_n) = C(F_1(x_1),\cdots,F_n(x_n);\theta) \quad (1)$$

Any multivariate joint distribution can be described in the form of equation (1). However, only if the margin $F_i(x_i)$ is continuous, the copula can be determined uniquely (Sklar, 1959). To date, various copulas have been developed, such as nested Archimedean copula, partial Archimedean copula, and Hierarchical Archimedean copula, as well as pair-copulas, which are targeted in this study. Copula has attractive advantages over conventional multivariate distribution functions. For example, different types of margins can be used to represent a same joint distribution, and the dependence structure can be flexibly specified (Nelson, 2006).

In the family of copulas, there are three special cases which are important for selecting copula (Nelson, 2006; Trivedi and Zimmer, 2007). *Independent copula* is a simple and basic one, written as a product function of margins, *comonotonicity copula* describes that a perfect positive dependence exists among the margins, and *countermonotonicity copula* expresses that the margins are negatively dependent upon each other. If a family of copulas includes the above three copulas, it is called as comprehensive (Nelson, 2006; Trivedi and Zimmer, 2007). Copula has a great variety of forms. However, the copulas that are often applied in literature are Gaussian copula, Farlie-Gumbel-Morgenstern (FGM) copula and Archimedean family of copula (e.g., Clayton, Gumbel, Frank and Joe copulas). Table 1 lists their copula functions and special cases, in which only Gaussian, FGM and Frank are comprehensive and their dependence parameters all cover both positive and negative domains (Nelson, 2006; Trivedi and Zimmer, 2007). In reality, either of positive and negative dependence might occur and it is also true for the tourist behavior under study. Therefore, Gaussian and Frank copulas will be adopted in this study. This study also tests FGM copula that can cover positive and negative domains, and accommodate only relatively weak dependence among margins.

Table 1. The Functions of Copulas

Copula	Expression	Special cases	θ domain
Gaussian	$\Phi(\Phi^{-1}(u_1), \Phi^{-1}(u_2); \theta)$	$C_{-1} = W, C_0 = \Pi, C_1 = M$	$-1 \le \theta \le 1$
FGM	$u_1 u_2 (1 + \theta(1 - u_1)(1 - u_2))$	$C_{-1} = W, C_0 = \Pi, C_1 = M$	$-1 \le \theta \le 1$
Clayton	$(u_1^{-\theta} + u_2^{-\theta} - 1)^{-1/\theta}$	$C_{\to 0} = \Pi, C_\infty = M$	$0 < \theta \le \infty$
Gumbel	$exp\left\{-[(-ln\, u_1)^\theta + (-ln\, u_2)^\theta]^{1/\theta}\right\}$	$C_1 = \Pi, C_\infty = M$	$1 \le \theta \le \infty$
Frank	$-\frac{1}{\theta} log\left(1 + \frac{(e^{-\theta u_1} - 1)(e^{-\theta u_2} - 1)}{e^{-\theta} - 1}\right)$	$C_{-\infty} = W, C_{\to 0} = \Pi, C_\infty = M$	$-\infty \le \theta \le \infty \backslash \{0\}$
Joe	$1 - [(1 - u_1)^\theta + (1 - u_2)^\theta - (1 - u_1)^\theta (1 - u_2)^\theta]^{1/\theta}$	$C_1 = \Pi, C_\infty = M$	$1 \le \theta \le \infty$

2.2 Pair copula

Pair copula is a collection of different bivariate copulas. Pair-copula construction (PCC) of a multivariate copula is hierarchical, where variables are sequentially incorporated into conditioning sets with a nested tree structure. PCC was first given by Joe (1996). Any dimensional multivariate joint distribution can be decomposed into PCC by using bivariate copulas. Since PCC is based on combinations of pairs of variables, when the number of variables increases, the number of possible combinations becomes larger and larger. To tackle the calculation difficulties caused by such large number of possible PCC, Bedford and Cook (2001, 2002) proposed a graphical method, named regular vines, which have two popular subclasses: D-vines and canonical vines. In this study, only D-vines and canonical vines are focused and descriptions of their generalized form (i.e., regular vines) are omitted (details can be found in Bedford and Cook (2001, 2002) and Czado (2010)).

We first consider three continuous random variables $\mathbf{X}\{x_1, x_2, x_3\}$ which follow a joint distribution function $F(x_1, x_2, x_3)$ with margins $F_1(x_1)$, $F_2(x_2)$ and $F_3(x_3)$, and has a joint density function $f(x_1, x_2, x_3)$ with margins $f_1(x_1)$, $f_2(x_2)$ and $f_3(x_3)$. The joint density function can be factorized into the following conditional density functions.

$$f(x_1, x_2, x_3) = f_3(x_3) f_{2|3}(x_2|x_3) f_{1|23}(x_1|x_2, x_3) \tag{2}$$

According to equation (1), joint density function $f(x_1, x_2, x_3)$ can also be written as,

$$f(x_1, x_2, x_3) = f_1(x_1) f_2(x_2) f_3(x_3) c_{123}(u_1, u_2, u_3) \tag{3}$$

where, $c_{123}(u_1, u_2, u_3)$ is copula density function, and u_1, u_2 and u_3 are $F_1(x_1)$, $F_2(x_2)$ and $F_3(x_3)$, respectively.

Based on equation (3), we can derive conditional density functions as follows,

$$f_{1|3}(x_1 \mid x_3) = f_1(x_1)c_{13}(u_1, u_3) \quad (4)$$
$$f_{2|3}(x_2 \mid x_3) = f_2(x_2)c_{23}(u_2, u_3) \quad (5)$$

and $f_{1|23}(x_1 \mid x_2, x_3)$ in the right side of equation (2) can also be rewritten as,

$$\begin{aligned} f_{1|23}(x_1 \mid x_2, x_3) &= f_{1|3}(x_1 \mid x_3)c_{12|3}(u_{1|3}, u_{2|3}) \\ &= f_1(x_1)c_{13}(u_1, u_3)c_{12|3}(u_{1|3}, u_{2|3}) \end{aligned} \quad (6)$$

where, $u_{1|3} = F_{1|3}(x_1 \mid x_3)$ and $u_{2|3} = F_{2|3}(x_2 \mid x_3)$.

Put equations (5) and (6) into equation (2), the joint density function can be represented as follows,

$$f(x_1, x_2, x_3) = f_1(x_1)f_2(x_2)f_3(x_3)c_{13}(u_1, u_3)c_{23}(u_2, u_3)c_{12|3}(u_{1|3}, u_{2|3}) \quad (7)$$

Furthermore, $F_{1|3}(x_1|x_3) = \dfrac{\partial C(u_1, u_3)}{\partial u_3}$ and $F_{2|3}(x_2|x_3) = \dfrac{\partial C(u_2, u_3)}{\partial u_3}$. From equation (7), it is easy to understand that the joint density can be decomposed into several two dimensional copula densities and corresponding marginal densities. This resulting construction is called as pair-copula construction (PCC). In the above way, PCC can be easily extended to cover higher dimensions.

However, as the dimension of a joint multivariate distribution increase, the number of possible PCC becomes considerable large. To tackle this issue, Bedford and Cook (2001, 2002) proposed D-vines and canonical vines. In D-vines, no node in any tree T_j is shared by more than two edges. In canonical vines, each tree T_j has a mere node that is connected to n-j edges, where n indicates the number of margins and j is the level of tress (Aas, Czado, Frigessi, and Bakken, 2006). Figures 1 and 2 show the constructions of D-vines and canonical vines with 4 margins and 3 trees, respectively. The type of D-vines is shown in equation (8) and that of canonical vines in equation (9).

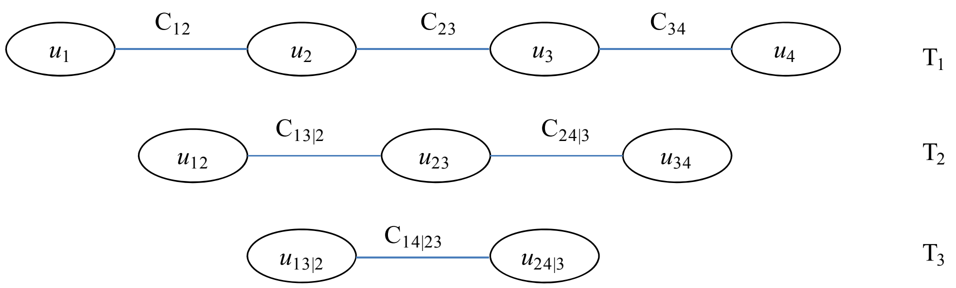

Figure 1. Four-Dimensional D-Vine Pair Copula Construction

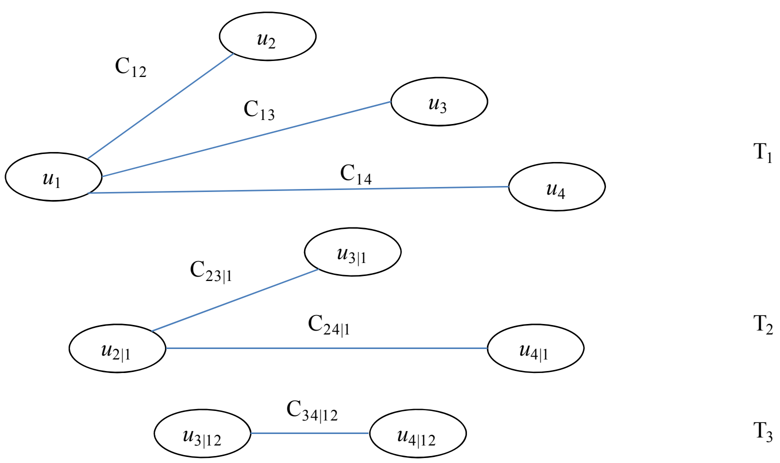

Figure 2. Four-Dimensional Canonical Vine Pair Copula Construction

$$f(x_1,x_2,x_3,x_4) = f_1(x_1)f_2(x_2)f_3(x_3)f_4(x_4)$$
$$c_{12}(u_1,u_2)c_{23}(u_2,u_3)c_{34}(u_3,u_4)$$
$$c_{13|2}(u_{1|2},u_{3|2})c_{24|3}(u_{2|3},u_{4|3}) \quad (8)$$
$$c_{14|23}(u_{1|23},u_{4|23})$$

$$f(x_1,x_2,x_3,x_4) = f_1(x_1)f_2(x_2)f_3(x_3)f_4(x_4)$$
$$c_{12}(u_1,u_2)c_{13}(u_1,u_3)c_{14}(u_1,u_4)$$
$$c_{23|1}(u_{2|1},u_{3|1})c_{24|1}(u_{2|1},u_{4|1}) \quad (9)$$
$$c_{34|12}(u_{3|12},u_{4|12})$$

Note that in 3-dimensional case of PCC, D-vines and canonical vines are the same as shown in equation (7). Expressions of high-dimensional PCC can be derived similarly.

3. TIME USE AND EXPENDITURE BEHAVIOR MODEL WITHOUT ZERO CONSUMPTION

Here, time use and expenditure behavior is modeled, given that destination visit and expenditure decisions are already made. In other words, a certain amount of time and money must be spent in each destination, but how much to spend is undecided. Note that zero consumption issue (i.e., a destination is not visited and/or no money is spent at destination) will be modeled later. Here, a multi-linear utility function (e.g., Bell, 1987; Zhang et al., 2005) is adopted to define tourist *i*'s utility u_i, derived from spending time and money at destination. It is assumed that tourist *i* maximizes his/her utility, given his/her limited time and expenditure budgets. More specifically,

$$Max \quad u_i = \sum_j (w_{ij}^t u_{ij}^t + w_{ij}^c u_{ij}^c) \quad (10)$$
$$+ \lambda_i^t \sum_j \sum_{j'\neq j} w_{ij}^t w_{ij'}^t u_{ij}^t u_{ij'}^t + \lambda_i^c \sum_j \sum_{j'\neq j} w_{ij}^c w_{ij'}^c u_{ij}^c u_{ij'}^c$$
$$+ \lambda_i^{tc} \sum_j w_{ij}^t w_{ij}^c u_{ij}^t u_{ij}^c$$
$$s.t. \quad \sum_j t_{ij} = T_i \quad (11)$$
$$\sum_j c_{ij} = C_i \quad (12)$$

where,

- i,j : tourist and activity,
- t_{ij} : activity time that tourist *i* spends at destination *j*,
- c_{ij} : expenditure level that tourist *i* spends at destination *j*,
- u_i : utility that tourist *i* derives from spending time and money at all destinations,
- u_{ij}^t : utility that tourist *i* derives from activity time t_{ij} at destination *j*,
- u_{ij}^c : utility that tourist *i* derives from expenditure level c_{ij} at destination *j*,
- w_{ij}^t : weight that tourist *i* attaches to destination *j* for activity time t_{ij},
- w_{ij}^c : weight that tourist *i* attaches to destination *j* for expenditure level c_{ij},
- λ_i^t : parameter of inter-destination interaction for activity time,
- λ_i^c : parameter of inter-destination interaction for expenditure level,
- λ_i^{tc} : parameter of inter-destination interaction for activity time and expenditure level,
- T_i : available time budget of tourist *i*, and
- C_i : available expenditure budget of tourist *i*.

Here, superscripts *t* and *c* are used to indicate that the corresponding notations are specific to activity time and expenditure level, respectively. Weight parameters w^t_{ij} and w^c_{ij} represent the relative importance that individual i attaches to destination j when determining activity time t_{ij} and expenditure level c_{ij}. Parameters λ^t_i, λ^c_i, and λ^{tc}_i describe three types of inter-destination interactions, which are defined in the form of a product of a pair of destination-specific utilities, as shown in the latter part of equation (10). Usually, it is realistic to assume that visiting a destination generates a positive utility. Accordingly, a positive value of interaction parameter means that inter-destination interaction increases the tourist's utility and a negative value indicates that the interaction induces competition among destination and consequently results in the occurrence of various conflicts.

The above modeling framework is similar to the traditional one (e.g., Becker, 1965; DeSerpa, 1971; Jara-Díaz, 2003), which however ignores the influence of inter-destination interactions. Here, income is not included in the monetary budget (equation (12)); instead, the total amount of money spent at all destinations is selected as a proxy of the budget constraint.

Equations (10) ~ (12) are based on the assumption that visiting destinations is pre-decided. It is also assumed that the total time and money budgets are fixed and pre-determined. The influence of destination visit behavior on time use and expenditure behavior will be illustrated in the next section. It is assumed here that the utility of time use or expenditure is positive. Meanwhile, the tourist might feel tired/bored after staying a certain length of time at a destination, or might worry about the affordability or question about the worthiness of further purchase. Thus, it seems reasonable to assume that marginal utility decreases with the increase of time or expenditure. To reflect this notion, equations (13) and (14) are adopted.

$$u^t_{ij} = \rho^t_{ij} \ln(t_{ij}) = \exp(\sum_k \beta^t_k x^t_{ijk} + e^t_{ij}) \ln(t_{ij}) \tag{13}$$

$$u^c_{ij} = \rho^c_{ij} \ln(c_{ij}) = \exp(\sum_k \beta^c_k x^c_{ijk} + e^c_{ij}) \ln(c_{ij}) \tag{14}$$

where,

x^t_{ijk} : attribute k that affects the utility u^t_{ij} of consuming activity time t_{ij},

β^t_k : parameter of attribute x^t_{ijk},

x^c_{ijk} : attribute k that affects the utility u^c_{ij} of expenditure level c_{ij},

β^c_k : parameter of attribute x^c_{ijk},

e^t_{ij} : error term of u^t_{ij}, and

e^c_{ij} : error term of u^c_{ij}.

Here, introducing x^t_{ijk} and x^c_{ijk} (mainly tourist's personal attributes and destination-specific attributes) into the utility function reflects the fact that different tourists may have different (or heterogeneous) responses to activity time and expenditure level. An exponential function is used to guarantee the positive requirement for the sign of the utility function. Error terms e^t_{ij} and e^c_{ij} are introduced to reflect the influence of unobservable factors (e.g., psychological factors: character and motivation; omitted factors: impulse and planned visit).

To derive the activity time and expenditure level functions, the Lagrange approach that combines the objective function (i.e., equation (10)) and its constraints (i.e., equations (11) and (12)) is adopted. Details refer to Zhang (2009). Here, only the resulting functions are shown below.

$$t_{ij} = \frac{\Psi^t_{ij}}{\sum_{j'} \Psi^t_{ij'}} T_i, \ \Psi^t_{ij} = w^t_{ij} \rho^t_{ij} (1 + \lambda^t_i \sum_{j' \neq j} w^t_{ij'} u^t_{ij'} + \lambda^{tc}_i w^c_{ij} u^c_{ij}) \tag{15}$$

$$c_{ij} = \frac{\Psi^c_{ij}}{\sum_{j'} \Psi^c_{ij'}} C_i, \ \Psi^c_{ij} = w^c_{ij} \rho^c_{ij} (1 + \lambda^c_i \sum_{j' \neq j} w^c_{ij'} u^c_{ij'} + \lambda^{tc}_i w^t_{ij} u^t_{ij}) \tag{16}$$

These functions will be used to represent tourists' time use and expenditure behavior in this study. Assuming the number of destinations visited is J, as a model system, there are $2*J$ functions in total. Hereafter, equation (15) is called the *activity time function* and equation (16) is called the *expenditure level function*.

Observing equations (15) and (16), it is obvious that the activity time (expenditure level) at destination j is influenced by not only the information of destination j itself, but also the information of other destinations. Taking the ratio of a pair of activity time (expenditure level) functions for destinations j and j' (see equations (17) and (18)), it is found that this ratio not only includes information about destinations j and j', but also information about the other destinations. This implies that the allocated activity time (expenditure level) to a destination is affected by the available destinations in a choice set, i.e., the IIA (Independence of Irrelevant Alternatives) property does not hold. This attractive feature is clearly owned to the introduction of inter-destination interactions.

$$\frac{t_{ij}}{t_{ij'}} = \frac{w_{ij}^t \rho_{ij}^t (1 + \lambda_i^t \sum_{j' \neq j} w_{ij'}^t u_{ij'}^t + \lambda_i^{tc} w_{ij}^c u_{ij}^c)}{w_{ij'}^t \rho_{ij'}^t (1 + \lambda_i^t \sum_{j'' \neq j'} w_{ij''}^t u_{ij''}^t + \lambda_i^{tc} w_{ij'}^c u_{ij'}^c)} \tag{17}$$

$$\frac{c_{ij}}{c_{ij'}} = \frac{w_{ij}^c \rho_{ij}^c (1 + \lambda_i^c \sum_{j' \neq j} w_{ij'}^c u_{ij'}^c + \lambda_i^{tc} w_{ij}^t u_{ij}^t)}{w_{ij'}^c \rho_{ij'}^c (1 + \lambda_i^c \sum_{j'' \neq j'} w_{ij''}^c u_{ij''}^c + \lambda_i^{tc} w_{ij'}^t u_{ij'}^t)} \tag{18}$$

Since the utility function defined in equation (1) is a function of both activity time and expenditure level, the value of activity time (VOAT) at destination j can be defined as follows.

$$VOAT_j = \frac{\partial u_i}{\partial t_{ij}} \bigg/ \frac{\partial u_i}{\partial c_{ij}} \tag{19}$$

Since the first derivatives $\frac{\partial u_i}{\partial t_{ij}}, \frac{\partial u_i}{\partial c_{ij}}$ are equal to the Lagrange coefficients, respectively, under the time and monetary constraints shown in equations (11) and (12), VOAT does not change with the type of destination. Thus, the two coefficients can be expressed below.

$$\frac{\partial u_i}{\partial t_{ij}} = \frac{1}{J} \sum_j \frac{\Psi_{ij}^t}{t_{ij}}, \frac{\partial u_i}{\partial c_{ij}} = \frac{1}{J} \sum_j \frac{\Psi_{ij}^c}{c_{ij}} \tag{20}$$

Excluding the error terms in the terms ρ_{ij}^t, ρ_{ij}^c, the common VOAT for all the activities can be rewritten as follows:

$$VOAT = \sum_j \frac{\tilde{\Psi}_{ij}^t}{t_{iji}} \bigg/ \sum_j \frac{\tilde{\Psi}_{ij}^c}{c_{ij}} \tag{21}$$

where,

$$\tilde{\Psi}_{ij}^t = w_{ij}^t \tilde{\rho}_{ij}^t (1 + \lambda_i^t \sum_{j' \neq j} w_{ij'}^t v_{ij'}^t + \lambda_i^{tc} w_{ij}^c v_{ij}^c) \tag{22}$$

$$\tilde{\Psi}_{ij}^c = w_{ij}^c \tilde{\rho}_{ij}^c (1 + \lambda_i^c \sum_{j' \neq j} w_{ij'}^c v_{ij'}^c + \lambda_i^{tc} w_{ij}^t v_{ij}^t) \tag{23}$$

$$v_{ij}^t = \tilde{\rho}_{ij}^t \ln(t_{ij}) \tag{24}$$

$$v_{ij}^c = \rho_{ij}^c \ln(c_{ij}) \tag{25}$$

$$\tilde{\rho}_{ij}^t = \exp(\sum_k \beta_k^t x_{ijk}^t) \tag{26}$$

$$\tilde{\rho}_{ij}^c = \exp(\sum_k \beta_k^c x_{ijk}^c) \tag{27}$$

$\widetilde{\Psi}^t_{ij}$ and $\widetilde{\Psi}^c_{ij}$ express the influence of observed factors on activity time and expenditure level by incorporating the influence of the inter-destination interactions.

Next, it will be described how to introduce the influence of destination visit behavior (i.e., whether to visit a destination or not) on time use and expenditure behavior.

4. TIME USE AND EXPENDITURE BEHAVIOR MODEL WITH ZERO CONSUMPTION

4.1 Model building

It is expected that error terms of activity time and expenditure level functions are correlated with each other. As seen in equations (13) and (14), error terms (e^t_{ij} and e^c_{ij}) are included in utility functions in a very complicated way. Therefore, it is difficult to directly represent the correlation between equations (15) and (16). For ease of model estimation, it is assumed that equations (15) and (16) can be re-written as follows:

$$t_{ij} = \frac{\widetilde{\Psi}^t_{ij}}{\sum_{j'} \widetilde{\Psi}^t_{ij'}} T_i + \varepsilon^t_{ij} \tag{28}$$

$$c_{ij} = \frac{\widetilde{\Psi}^c_{ij}}{\sum_{j'} \widetilde{\Psi}^c_{ij'}} C_i + \varepsilon^c_{ij} \tag{29}$$

Here, ε^t_{ij} and ε^c_{ij} are the newly introduced error terms of activity time and expenditure level functions, respectively, and in theory, they can follow any probability distributions. It is further implicitly assumed that equations (28) and (29) do not violate the time and monetary constraints defined in equations (11) and (12). Mathematically, such assumed transformation is not problematic, but it is surely difficult to clarify a clear relationship between the original and newly-introduced error terms. This assumption is made for the sake of incorporating the influence of various error terms in an easier and more flexible way. $\widetilde{\Psi}^t_{ij}$ and $\widetilde{\Psi}^c_{ij}$ are shown in equations (22) and (23), respectively.

Behaviorally, prior to decisions on activity time and expenditure level, a tourist needs to make decisions on whether to visit a destination or not, and in case of the visit, whether to spend any money at the destination. Let y^t_{ij} be a latent variable representing the decision on destination visit, and y^c_{ij} be a latent variable explaining the decision on expenditure. Here, it is assumed that when y^t_{ij} is larger than zero, the tourist decides to visit a destination, and when y^c_{ij} is larger than zero, the tourist decides to spend some money at destination. Therefore, a nested Tobit type of model system can be specified as:

$$y^t_{ij} = \sum_s \gamma^t_s z^t_{ijs} + \eta^t_{ij} \tag{30}$$

$$y^c_{ij} = \sum_s \gamma^c_s z^c_{ijs} + \eta^c_{ij} \tag{31}$$

$$\begin{cases} \begin{cases} t_{ij} = \widetilde{\Delta}^t_{ij} T_i + \varepsilon^t_{ij} \\ \begin{cases} c_{ij} = \widetilde{\Delta}^c_{ij} C_i + \varepsilon^c_{ij} & if\ y^c_{ij} > 0 \\ c_{ij} = 0 & if\ y^c_{ij} \le 0 \end{cases} \end{cases} & if\ y^t_{ij} > 0 \\ t_{ij} = 0 & if\ y^t_{ij} \le 0 \end{cases} \tag{32}$$

$$\widetilde{\Delta}^t_{ij} = \frac{\widetilde{\Psi}^t_{ij}}{\sum_{j'} \widetilde{\Psi}^t_{ij'}} \tag{33}$$

$$\widetilde{\Delta}_{ij}^{c} = \frac{\widetilde{\Psi}_{ij}^{c}}{\sum_{j'} \widetilde{\Psi}_{ij'}^{c}} \tag{34}$$

$$\eta_{ij}^{t} \sim N\left(0, \left(\sigma_{j}^{yt}\right)^{2}\right) \tag{35}$$

$$\eta_{ij}^{c} \sim N\left(0, \left(\sigma_{j}^{yc}\right)^{2}\right) \tag{36}$$

where, z_{ijs}^{t} and z_{ijs}^{c} are factors affecting tourist *i*'s decisions on the visit of destination *j* and expenditure during visiting destination *j* with a parameter γ_s^t and γ_s^c, respectively.

It is obvious that the Tobit model involving expenditure decision is nested under y_{ij}^{t}. Hereafter, equation (30) is called the *destination visit decision function* and equation (31) is called the *expenditure decision function.* Two decisions (i.e., whether to visit a destination and whether to spend any money) explicitly influences the allocation results of time and money at the same time. It is obvious that: 1) if y_{ij}^{t} and y_{ij}^{c} are larger than zero at the same time, then t_{ij} and c_{ij} are observed; 2) if y_{ij}^{t} is greater than zero and y_{ij}^{c} is equal or less than zero, then only t_{ij} is observed; 3) if y_{ij}^{t} is equal or less than zero, then t_{ij} cannot be observed, and at the same time, c_{ij} cannot be observed, either. Therefore, tourists' decisions on whether to visit a destination play a key role in the whole tour.

The likelihood function of the above-developed tourist time use and expenditure model with zero consumption can be written as,

$$L = \prod_i \prod_j \left[\begin{array}{l} \left\{ \Pr\left(y_{ij}^{t} \le 0\right) \right\}^{d_{ij}^{t}=0} \\ \left\{ \begin{array}{l} \left[f\left(t_{ij} \mid y_{ij}^{c} \le 0, y_{ij}^{t} > 0\right) \Pr\left(y_{ij}^{c} \le 0 \mid y_{ij}^{t} > 0\right) \Pr\left(y_{ij}^{t} > 0\right) \right]^{d_{ij}^{c}=0} \\ \left[f\left(t_{ij}, c_{ij} \mid y_{ij}^{c} > 0, y_{ij}^{t} > 0\right) \Pr\left(y_{ij}^{c} > 0 \mid y_{ij}^{t} > 0\right) \Pr\left(y_{ij}^{t} > 0\right) \right]^{d_{ij}^{c}=1} \end{array} \right\}^{d_{ij}^{t}=1} \end{array} \right] \tag{37}$$

where dummy variables (*d*) have the following values.

$d_{ij}^{t} = 1$ if tourist *i* decides to visit destination *j* (i.e., to spend a certain length of time),

$d_{ij}^{t} = 0$ if tourist *i* decides not to visit destination *j*,

$d_{ij}^{c} = 1$ if tourist *i* decides to spend some money at destination *j*, given $d_{ij}^{t} = 1$, and

$d_{ij}^{c} = 0$ if tourist *i* decides not to consume any money at destination *j*, given $d_{ij}^{t} = 1$.

4.2 Introducing pair copula

Here, pair copulas are applied to calculate the conditional joint distributions included in the above likelihood function. In the right side of equation (37), there are two conditional multivariate joint distributions. The first one can be rewritten in the following form based on 3-dimensional PCC.

$$\begin{aligned} & f\left(t_{ij} \mid y_{ij}^{c} \le 0, y_{ij}^{t} > 0\right) \Pr\left(y_{ij}^{c} \le 0 \mid y_{ij}^{t} > 0\right) \Pr\left(y_{ij}^{t} > 0\right) \\ & = f\left(t_{ij}\right) c\left(F\left(t_{ij}\right), F\left(y_{ij}^{t} > 0\right)\right) c\left(F\left(t_{ij} \mid y_{ij}^{t} > 0\right), F\left(y_{ij}^{c} \le 0 \mid y_{ij}^{t} > 0\right)\right) \\ & \quad C\left(F\left(y_{ij}^{c} \le 0\right), F\left(y_{ij}^{t} > 0\right)\right) \end{aligned} \tag{38}$$

However, the second one concerns four dimensional multivariate joint distribution, and it can be decomposed into two possible PCCs, i.e., D-vines and canonical vines. As mentioned previously, the critical determinant in the whole tour is the decision on whether to visit a destination or not, that is, $y_{ij}^{t} > 0$ is the underlying factor. Hence, this study adopts the type of canonical vines PCC, i.e., in the tree T_1, $y_{ij}^{t} > 0$ is connected to activity time and expenditure level decisions, respectively. In the tree T_2, each margin is the function subject to $y_{ij}^{t} > 0$. In the tree T_3, both of activity time and expenditure level functions are subject to $y_{ij}^{t} > 0$ and $y_{ij}^{c} > 0$. Therefore, the joint distribution conditional on $f\left(y_{ij}^{t} > 0, y_{ij}^{c} > 0\right)$ becomes,

$$
\begin{aligned}
& f\left(t_{ij}, c_{ij} \mid y_{ij}^{c} > 0, y_{ij}^{t} > 0\right) \Pr\left(y_{ij}^{c} > 0 \mid y_{ij}^{t} > 0\right) \Pr\left(y_{ij}^{t} > 0\right) \\
&= f\left(t_{ij}\right) f\left(c_{ij}\right) c\left(F\left(t_{ij}\right), F\left(y_{ij}^{t} > 0\right)\right) c\left(F\left(c_{ij}\right), F\left(y_{ij}^{t} > 0\right)\right) \\
&\quad c\left(F\left(t_{ij} \mid y_{ij}^{t} > 0\right), F\left(y_{ij}^{c} > 0 \mid y_{ij}^{t} > 0\right)\right) c\left(F\left(c_{ij} \mid y_{ij}^{t} > 0\right), F\left(y_{ij}^{c} > 0 \mid y_{ij}^{t} > 0\right)\right) \\
&\quad c\left(F\left(t_{ij} \mid y_{ij}^{c} > 0, y_{ij}^{t} > 0\right), F\left(c_{ij} \mid y_{ij}^{c} > 0, y_{ij}^{t} > 0\right)\right) \\
&\quad C\left(F\left(y_{ij}^{c} > 0\right), F\left(y_{ij}^{t} > 0\right)\right)
\end{aligned}
\qquad (39)
$$

where, $c(\bullet)$ is copula density and $C(\bullet)$ is copula function.

The model system consisting of equations (30) ~ (39) is called "*nested time use and expenditure model with multi-destination visit* (NTUEMD)" model. It is, in fact, a new nested multiple discrete-continuous choice model, which can be estimated by the standard maximum likelihood method.

Here, three types of copulas, i.e., Gaussian, FGM and Frank, which meet the comprehensive requirement of copula, are applied to calculate the likelihood function, and the best one will be selected based on the goodness-of-fit to data.

5. DATA

To examine the effectiveness of the developed NTUEMD model, this study employs a tourist behavior questionnaire survey data collected in Tottori Prefecture, Japan, in 2007. In the model estimation described later, Tottori Prefecture will be divided into three destinations (eastern, middle and western areas), but in the questionnaire survey, touring information was reported at the detailed spot level. Respondents were asked to fill in concrete names of touring spots visited and for each sport, time use (measured by departure and arrival time) and expenditure (the amount of money spent), and travel modes used were reported. In addition, tourists' subjective evaluation about major touring spots and individual attributes are also included in the questionnaire.

Tottori Prefecture is located in the western part of Honshu Island and nearby the Sea of Japan. It is famous for its sand dunes, beautiful beaches, a variety of seasonal sceneries, hot springs, Nijisseiki Pear (the king of all Japanese pears), and sea foods, etc. The number of tourists was 9.823 millions in 2009, and it was only 10% higher than the number in 1999, failing to increase as much as expected. According to the statistics by Tottori Prefecture, about 73% of tourists in 2009 were day trippers.

In total, 6,585 questionnaires were randomly distributed to tourists at major attractions and tourist information offices in the four seasons of the year 2007. As a result, 761 respondents returned the questionnaires with valid answers. Survey results show that 56% of tourists were day trippers and 44% stayed for one or more nights in Tottori Prefecture, and 92% of respondents were tourists travelling by car. The tourists travelling with family accounted for 78%, among which 48% were the couple.

As a case study, this study only focuses on day trippers. With the above data screening, the data from 301 day trippers is adopted.

6. ESTIMATION RESULTS AND DISCUSSION

6.1 Dependent and explanatory variables

The above-extracted 301 tourists made a one-day trip within Tottori Prefecture. Since each tourist visited at least one destination, the number of tourists visiting the first destination is 301. And, the numbers of tourists visiting the second and third destinations are 192 and 81, respectively. Table 2 shows the shares of tourists who visited each destination and spent money there, respectively. Since there are four dependent variables for each destination: y^t_{ij}, y^c_{ij}, t_{ij}, and c_{ij}, the total number of dependent variables in this study is twelve. Statistical features of activity time (t_{ij}) and expenditure level (c_{ij}) are summarized in Table 3. The average activity time (i.e., the total time staying at each destination) ranges from 60 to 99 minutes, and the average expenditure level from 1,325 to 1769 Japanese Yen. Interestingly, the first destination shows the longest activity time and highest expenditure level, suggesting that most tourists might treat the first destination as the most important destination.

Table 2. Shares of Tourists Who Visited Destinations and Spent Money at Destinations

Destinations	Share of tourists who visited	Share of tourists who spent money
The first destination	100%	89%
The second destination	64%	57%
The third destination	27%	22%

Based on an incomplete trial-and-error cross-aggregation analysis and the estimation results of existing models, eleven explanatory variables were selected, including individual attributes and destination attributes. The individual attributes include age, gender (0: male; 1: female), residential location (1: outside Tottori Prefecture; 0: otherwise), size of travel party (number of persons traveling together) and access travel time (travel time from home to destination). The destination attributes include number of natural spots, number of parks, number of beaches, number of heritages, spa dummy (1: if a destination has any spa resource; 0: otherwise) and gourmet dummy (1: if a destination has any special local food; 0: otherwise). In addition to the above two types of variables, four constant terms are further introduced into activity time function, expenditure level function, destination visit decision function and expenditure decision function, where the constant terms related to the first destination are treated as references.

Table 3. Statistical Features of Time Use and Expenditure

Destinations	Minimum	Maximum	Mean	Standard deviation
Activity time (minute)				
The first destination	5	780	99	90
The second destination	3	495	83	76
The third destination	10	330	60	58
Expenditure (Yen)				
The first destination	24	35,000	1,769	2,686
The second destination	40	14,750	1,539	1,686
The third destination	30	11,500	1,325	1,638

6.2 Estimation results

The three types of NTUEMD models are estimated by using a maximum likelihood method via two steps, as suggested by Trivedi and Zimmer (2007). That is, an Independence model without any dependence parameters is first estimated and then the estimated parameters of explanatory variables are used as initial values to estimate the model with copula, together with the dependence parameters. Totally, there are nine dependence parameters: three for time use behavior and the others for expenditure behavior. Since the sample size is not larger enough and especially for the third site only 81 samples are available, we assume that all the parameters cross three destinations are the same. Estimation results are shown in Table 4.

6.2.1 Model accuracy

Model accuracy is first evaluated based on the following Bayesian Information Criterion (BIC),

$$BIC = -ln(L) + 0.5K \times ln(N) \quad (40)$$

where, $ln(L)$ is the converged log-likelihood value, K is the number of parameters estimated, and N is the sample size. Smaller value of the BIC means higher model accuracy. In this sense, the BIC is a relative model accuracy indicator.

Table 4. Model Estimation Results

Explanatory Variables	Independent Copula		Frank-PCC Copula		FGM-PPC Copula		Gaussian-PPC Copula	
	Parameter	t score	Parameter	t score	Parameter	t score	Parameter	t score
Destination Visit Decision Function								
Constant term	-1.640	-13.50	-1.552	-15.48	-1.640	-13.56	-1.729	-18.09
Individual Attributes								
Residential location	0.874	3.67	0.776	3.78	0.874	3.66	0.971	3.24
Access travel time	0.013	7.50	0.010	8.18	0.013	8.12	0.004	6.37
Destination Attributes								
Number of natural spots	0.507	5.48	0.475	4.72	0.507	6.18	0.625	8.41
Number of beaches	0.569	1.72	0.567	4.60	0.569	1.73	0.578	5.63
Spa dummy	0.612	1.81	0.543	1.88	0.612	1.86	0.636	2.93
Activity Time Function								
Constant term	0.506	0.92	0.421	0.68	0.506	1.09	0.405	0.69
Individual Attributes								
Age	0.252	0.77	0.187	0.55	0.252	0.93	0.312	1.99
Size of travel party	0.189	0.44	0.259	0.64	0.189	0.55	0.189	0.52
Gender (male: 0 ; female: 1)	1.592	3.79	1.552	2.43	1.592	4.61	1.707	5.35
Residential location	1.145	2.58	1.165	2.75	1.145	3.70	1.036	2.17
Destination Attributes								
Number of natural spots	0.503	4.17	0.291	5.32	0.503	5.22	0.477	2.93
Number of parks	0.176	1.81	0.352	2.98	0.176	3.34	0.228	1.46
Number of beaches	-0.076	-0.22	-0.087	-0.26	-0.076	-0.23	-0.194	-3.52
Spa dummy	-0.265	-0.69	-0.254	-1.52	-0.265	-0.85	-0.296	-0.62
Gourmet dummy	0.215	0.45	0.394	3.88	0.215	0.52	0.053	0.79
Expenditure Decision Function								
Constant term	0.223	0.27	0.275	0.11	0.223	0.22	0.291	0.45
Individual Attributes								
Residential location	0.050	0.02	0.187	0.12	0.050	0.02	0.116	0.11
Size of travel party	-0.695	-0.42	-0.758	-0.63	-0.695	-0.45	-0.674	-1.01
Access travel time	0.032	4.43	0.047	3.56	0.032	30.86	0.037	4.84
Destination Attributes								
Number of natural spots	-0.403	-0.93	-0.572	-0.92	-0.403	-1.06	-0.686	-6.17
Number of beaches	0.720	5.11	0.635	5.22	0.720	8.01	0.761	12.23
Number of heritages	1.061	6.96	1.031	3.77	1.061	8.91	0.970	5.17
Spa dummy	-1.317	-1.22	-1.399	-1.27	-1.317	-1.30	-1.452	-2.59
Gourmet dummy	-0.625	-5.97	-0.600	-2.29	-0.625	-4.44	-0.594	-4.19
Expenditure Level Function								
Constant term	1.077	2.28	1.134	0.96	1.077	3.20	1.022	3.18
Individual Attributes								
Age	1.033	4.43	1.256	3.36	1.033	4.82	1.003	9.68
Size of travel party	1.528	2.92	1.345	4.89	1.528	4.17	1.454	4.93
Access travel time	0.003	0.76	0.003	0.58	0.003	0.99	-0.007	-2.57
Destination Attributes								
Number of natural spots	0.028	0.25	-0.107	-1.02	0.028	0.27	-0.155	-1.87
Number of beaches	0.917	4.53	0.932	5.30	0.917	4.87	0.863	5.92
Number of heritages	-0.092	-1.12	0.013	0.20	-0.092	-1.26	-0.032	-0.49
Gourmet dummy	-0.912	-1.53	-0.880	-1.62	-0.912	-1.96	-1.060	-2.75

As shown in Table 4, the BIC values are: 3227.0 for the Independence model, 3033.6 for the Frank-PCC based NTUEMD model, 3101.6 for the FGM-PCC model, and 3124.4 for the Gaussian-PCC model. It is obvious that the BIC value of the Independence model is largest among the results and the Frank-PCC model has the lowest BIC value. In other words, all the PCC models perform better than the Independent model and the Frank-PCC model is superior to any of the other three models. Moreover, all the variance parameters in the model are significant, too. The above results suggest that the tourist behavior model with the Frank-PCC is more suitable. Hereafter, the results of Frank-PCC will be mainly explained.

6.2.2 Dependence structure

For the Frank-PCC based NTUEMD model, except $\theta\left(y^t > 0, y^c \le 0\right)$ of the 3-dimension copula, all the other eight dependence parameters are statistically significant at the 95% level. The three dependence parameters belonging to the 3-dimension copula are all negative and in contrast, five out of six parameters are positive ($\theta(c, y^c > 0 \mid y^t > 0)$ is negative). These results suggest that the developed model structure is statistically supported. The meanings of the dependence parameters can be interpreted as follows:

Table 4. Model Estimation Results (continued)

Explanatory Variables	Independent Copula		Frank-PCC Copula		FGM-PPC Copula		Gaussian-PPC Copula	
	Parameter	t score	Parameter	t score	Parameter	t score	Parameter	t score
Relative Interest Parameter								
Activity time								
w_1 (First destination)	0.471	-	0.477	-	0.471	-	0.468	-
w_2 (Second destination)	0.203	3.86	0.195	2.64	0.203	4.04	0.176	3.24
w_3 (Third destination)	0.327	1.73	0.328	1.06	0.327	1.49	0.356	2.72
Expenditure level								
w_1 (First destination)	0.311	-	0.316	-	0.311	-	0.302	-
w_2 (Second destination)	0.351	0.38	0.387	0.58	0.351	0.86	0.370	0.61
w_3 (Third destination)	0.338	0.28	0.297	0.21	0.338	1.36	0.328	0.09
Variance Parameter								
Activity time								
σ_1^2 (First destination)	1.555	17.63	1.661	13.04	1.555	19.55	1.756	42.82
σ_2^2 (Second destination)	2.880	6.24	2.859	10.76	2.880	18.14	2.877	97.24
σ_3^2 (Third destination)	1.762	8.49	1.684	10.77	1.762	11.14	1.663	31.83
Expenditure								
σ_1^2 (First destination)	3.509	16.73	3.426	3.22	3.509	7.38	3.542	1.70
σ_2^2 (Second destination)	2.517	16.98	2.502	22.17	2.517	18.28	2.380	63.76
σ_3^2 (Third destination)	3.840	9.24	3.708	9.54	3.840	9.70	3.892	17.87
Expenditure level								
σ_1^2 (First destination)	1.311	6.03	1.309	4.90	1.311	5.30	1.351	10.09
σ_2^2 (Second destination)	5.316	10.30	5.166	3.56	5.316	7.92	4.966	27.31
σ_3^2 (Third destination)	4.757	5.88	4.758	2.86	4.757	14.78	4.788	7.83
Inter-Destination Interaction (λ)								
Time-to-time	1.134	4.76	1.068	3.81	1.134	4.97	1.211	1.02
Expenditure-to-expenditure	1.107	2.73	1.116	1.99	1.107	2.88	1.231	1.43
Time-to-expenditure	2.335	8.38	2.391	3.51	2.335	8.48	2.347	74.89
Copula Parameter (θ)								
3-Dimension Copula Function								
$\theta(t,y^t>0)$	-	-	-3.757	-6.80	-0.649	-2.88	-0.698	-56.92
$\theta(y^t>0,y^c\leq 0)$	-	-	-0.169	-0.21	0.592	0.88	-0.548	-19.95
$\theta(t,y^c\leq 0 \mid y^t>0)$	-	-	-5.413	-6.32	0.375	1.25	-0.706	-55.66
4-Dimension Copula Function								
$\theta(t,y^t>0)$	-	-	1.001	16.72	0.059	0.17	-0.222	-5.82
$\theta(y^t>0,y^c>0)$	-	-	2.604	2.91	0.496	1.73	-0.585	-99.00
$\theta(c,y^t>0)$	-	-	1.697	2.06	-0.192	-14.97	-0.220	-6.98
$\theta(t,y^c>0 \mid y^t>0)$	-	-	2.787	5.97	0.827	10.44	0.665	48.31
$\theta(c,y^c>0 \mid y^t>0)$	-	-	-0.476	-2.27	0.336	1.19	0.148	3.06
$\theta(t,c \mid y^t>0,y^c>0)$	-	-	3.776	9.11	0.918	6.81	0.378	17.16
Log-likelihood at convergence	-3061.517		-2868.052		-2936.102		-2958.868	
BIC	3227.023		3033.558		3101.608		3124.374	
Sample size	301							

For the 3-dimension copula, the negative value of $\theta(t, y^t > 0)$ means that tourists' destination visits results in a shorter stay at destinations, while the negative value of $\theta(t, y^c \leq 0 \mid y^t > 0)$ indicates that conditional on that destination visit is decided, deciding not to spend any money results in a shorter stay at destination.

For the 4-dimension copula, the negative value of $\theta(c, y^c > 0 \mid y^t > 0)$ means that conditional on that a destination visit is decided, deciding to spend some money does not lead to more expenditure at destination. Other positive values of dependence parameters suggest that deciding to visit a destination results in a longer stay and spending more money at the destination, and the longer the time spent at a destination, the higher the expenditure spent, and vice versa.

One can see that various behavioral dependencies can be explicitly observed from the NTUEMD model. Such modeling approach could allow policy makers to examine the effects of policies in a comprehensive and consistent way.

6.2.3 Relative importance parameters and inter-destination interaction parameters

Only one relative importance parameter (i.e., activity time function of the second destination: 0.195) is significant statistically. All the relative importance parameters for expenditure level function are insignificant. In spite of the statistical insignificance, the values of relative importance parameters suggest that tourists surely attach different importance to different destinations. Even though the reasons of such statistical insignificance are unclear, it might be worth introducing tourists' (observed and unobserved) heterogeneity into the model.

The inter-destination interaction parameters are all positive and statistically significant at the 95% level in the Frank-PCC model. The positive interaction parameters mean that the constraints of limited time and monetary budgets do not necessarily reduce tourists' utility, as expected initially; rather, tourists benefit more from the trade-off of time and money resources due to the constraints. The copula represents dependence mechanisms caused by unobserved factors; in contrast, inter-destination interactions explain dependence mechanisms based on observed information. Thus, jointly adopting the copula and inter-destination interaction concepts allows us to represent the dependence mechanisms in a systematic way.

6.2.4 Influential factors

In total, there are 29 explanatory variables and 4 constant terms introduced into the Frank-PPC based NTUEMD model (same as other three models) (see Table 4). Comments are mainly given only with respect to those statistically significant variables.

Destination visit: tourists living far from Tottori Prefecture are more likely to visit Tottori Prefecture for tourism activities. And the more the tourism resources (the numbers of natural spots and beaches, and the spa resource) are, the more likely tourists visit.

Activity time: Female tourists and those tourists living far from Tottori Prefecture tend to spend more time at destinations. Natural spots and parks as well as gourmet encourage tourists to stay longer; however, beaches and spa are not influential at all.

Expenditure decision: Tourists living far from Tottori Prefecture are more likely to spend money at destinations. Beaches and heritages encourage tourist to spend money and in contrast, gourmet does not encourage tourists' expenditure decisions.

Expenditure level: Older tourists and those with larger travel party are more likely to spend more money at destinations. Only beaches lead to more expenditure and other destination attributes are not influential at all.

For the four introduced constant terms, only that for the destination visit function is found to be statistically significant. Negative sign suggests, however, that those omitted and unobserved factors keep tourists away from visiting Tottori Prefecture, on average. This is a very important finding. As mentioned in Section 4, the growth rate of tourists visiting Tottori Prefecture is quite low in recent years. Such unobserved factors should be further explored for more effective tourism policies.

6.2.5 VOAT

As an application of the developed model, here, the tourist's value of activity time (VOAT) is measured. The average VOAT of tourists in Tottori Prefecture is 19.74 Yen/minute. Furthermore, the average VOATs are also calculated with respect to several different origin prefectures (see Figure 3). The highest score, 26.43 Yen/minute, is obtained from those tourists coming from Hyogo Prefecture, and the tourists from Kyoto show the lowest score, 0.75 Yen/minute. Meanwhile, tourists from Tottori Prefecture have the VOAT of 21.87 Yen/minute. In 2007, the annual disposable income per person was about 3,271,840 Yen by Japanese official statistics, and assuming that a tourist has 12 hours free time per day and 118 holidays per year (including two-day weekends and Japanese traditional holidays and so on), the value of disposable time is 38.51 Yen/minute. Thus, the above-calculated VOATs seem not unrealistic.

7. CONCLUSIONS

Generally speaking, an individual's time use and expenditure behavior, irrespective of daily and non-daily travel, is influenced by where he/she performs activities, but visiting a destination does not mean that he/she must spend some money there. In case of multi-destination visit, the individual decision-making becomes more complicated. Focusing on tourist behavior, this study developed a nested time use and expenditure behavior model with multi-destination visit based on pair copula. The model is an extension of an existing multi-destination model developed by the authors (Zhang et al., 2012). As the extension, this study still adopts the basic structure of utility-maximizing time use and expenditure behavior model with multi-linear utility functions. Different from the authors' previous model, this study simultaneously represents tourists' decisions on whether to visit a destination or not and whether to spend any money there as well as their influence on activity time and expenditure level (i.e., the amount of money) decisions. Behaviorally, activity time decision and expenditure-related decisions are conditional on destination visit decision, and expenditure level decision is further conditional on expenditure decision. To accommodate such complicated decision structure, a nested Tobit modeling technique and a type of canonical vines Pair-Copula Construction (PCC) are jointly applied.

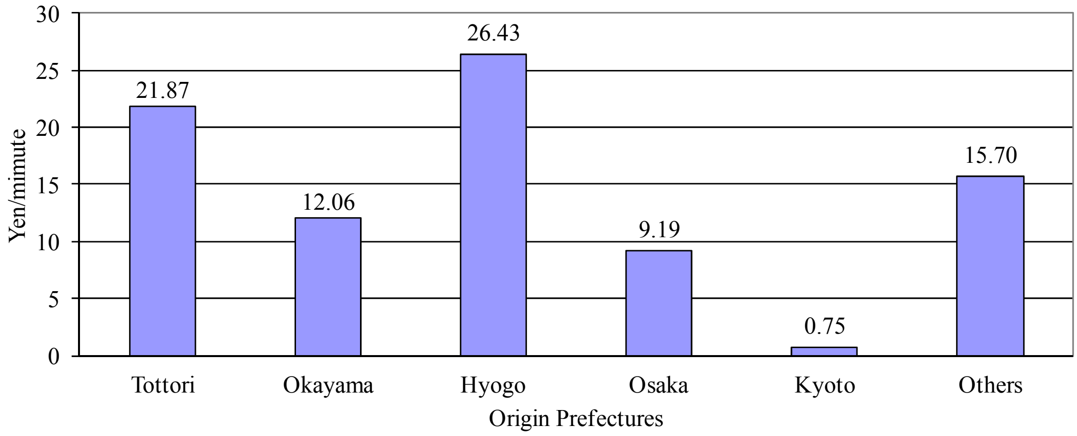

Figure 3. VOATs by Tourists' Origins

Using a questionnaire data collected from tourists (only day trippers: 301 samples) visiting Tottori Prefecture, Japan in 2007, the effectiveness of the developed model was empirically confirmed. Concerning the dependence structures introduced in the model, two types of them are estimated to be significant: the first type includes three dependence parameters for activity time decision, and the second one includes six dependence parameters for decisions on both time use and expenditure. Positive interactions between activity time decisions, between expenditure decisions, and between both activity time and expenditure decisions are revealed, suggesting that competition among these resources increases tourists' utility. This is a different finding from daily activity-travel behavior. As a transport policy variable, actual access travel time in the destination visit and expenditure decision functions got positive values, suggesting that tourists prefer a long-distance journey to enjoy their holidays. Finally, it is also found that values of activity time differ considerably across tourists' origins.

The development of the above tourist time use and expenditure behavior model has various implications. First, the calculated activity time and expenditure level from the model are two of the most important indicators to evaluate the effects of tourism policies. Second, the joint calculation of activity time and expenditure level is useful to properly measure the effects of tourism policies based on cost-benefit analysis. Separate calculation of activity time and expenditure level might lead to seriously biased evaluation and misleading tourism policy decisions. Third, the confirmed positive inter-destination interactions for time use and/or expenditure suggest the necessity of cross-destination collaboration. Fourth, different values of activity time suggest that tourism policies and marketing activities should be origin-specific in order to enhance the quality and effects of tourism policies and marketing activities. Fifth and finally, positive parameters of access travel time imply that it is also necessary to deploy marketing activities in those more remote areas.

Having summarized the findings of this study, it should be emphasized that there are still several unresolved research issues. First, the model should be re-examined by using different types of tourism behavior data. Second, it might be worth exploring a more general error term structure (e.g., non-normal distributions and more flexible copulas). Third, more general functions of time use utility and expenditure utility should be introduced to reflect more realistic decision-making mechanisms. Fourth, tourists' context-sensitive behavior (Zhang et al., 2009) should be represented. Fifth, it is worth exploring how to represent decisions on the time and monetary budgets. Sixth, it is necessary to explore how to select proper explanatory variables to describe such complicated behavior. Finally, the model should be applied to examine the effects of various tourism policies and marketing activities.

ACKNOWLEDGEMENT

This research is supported by the Grants-in-Aid for Scientific Research (A) ‘‘Development of Cross-Sector Urban Planning and Management Methodologies by Establishing Theory of Citizens’ Life Decisions and Behavior (Principal Researcher: Prof. Dr. Junyi Zhang, Hiroshima University)’’ (No.22246068) of the Japan Society for the Promotion of Science (JSPS), Japan (Details: http://home.hiroshima-u.ac.jp/hitel/citi_qol.html).

REFERENCES

1) Aas, K., and Berg, D. (2009). Models for construction of multivariate dependence: A comparison study. *The European Journal of Finance*, 15, 639-659.
2) Aas, K., Czado, C., Frigessi, A., and Bakken, H. (2009). Pair-copula constructions of multiple dependence. *Insurance, Mathematics and Economics*, 44, 182-198
3) Amemiya, T. (1984). Tobit Models: A Survey. *Journal of Econometrics*, 24, 3-61.
4) Becken, S., and Gnoth, J. (2004). Tourist consumption systems among overseas visitors: Reporting on American, German, and Australian visitors to New Zealand. *Tourism Management*, 25, 375-385.
5) Becker, G. (1965). A theory of the allocation of time. *The Economic Journal*, 75, 493-517.
6) Bedford, T., and Cooke, R.M. (2001). Probability density decomposition for conditionally dependent random variables modeled by vines. *Annals of Mathematics and Artificial Intelligence*, 32, 245-268.
7) Bedford, T., and Cooke, R.M. (2002). Vines-a new graphical model for dependent random variables. Annals of Statistics, 30(4), 1031-1068.
8) Bell, D.E. (1978) Multilinear representations for ordinal utility functions. *Journal of Mathematical Psychology* 31, 44-59.
9) Berg, D., and Aas, K. (2007). Models for construction of multivariate dependence. *Norwegian Computing Center Technical Report*.
10) Bhat, C.R. (2005). A multiple discrete-continuous extreme value model: Formulation and application to discretionary time-use decisions. *Transportation Research Part B*, 39(8), 679-707.
11) Buhalis, D. (2000). Marketing the competitive destination of the future. *Tourism Management*, 21(1), 97-116.
12) Bull, A. (1991) *The Economics of Travel and Tourism*. Melbourne, Longman Cheshire.
13) Cesario, F. (1976). Value of Time in Recreation Benefit Studies. *Land Economics*, 52, 32-41.
14) Chen, C., and Mokhtarian, P.L. (2000). Modeling Individuals’ Travel Time and Money Expenditures. *Research Report prepared for the Daimler Chrysler Corporation*, Institute of Transportation Studies. University of California, Davis, March.
15) Cooper, C.P. (1981). Spatial and temporal patterns of tourist behavior. *Regional Studies*, 15(5), 359-371.
16) Crouch, G., and Dolnicar, S. (2005). Tourism discretionary spending choice behavior. *Conference Proceedings of the Australian and New Zealand Marketing Academy*, Fremantle, Western Australia, December 5-7 (CD-ROM).
17) Dellaert, B.G.C., Ettema, D.F., and Lindh, C. (1998). Multi-faceted tourist travel decisions: a constraint-based conceptual framework to describe tourists’ sequential choices of travel components. *Tourism Management*, 19 (4), 313-320.
18) DeSerpa, A.C. (1971). A theory of the economics of time. *Economic Journal*, 81 (324), 828-846.
19) Fennell, D.A. (1996). A tourist space-time budget in the Shetland islands. *Annals of Tourism Research*, 23(4), 811-829.
20) Fujiwara, A., and Zhang, J. (2005). Development of car tourists' scheduling model for 1-day tour. *Transportation Research Record*, 1921, 100-111.
21) Habib, K.M., Carrasco, J.A., and Miller, E.J. (2008). Discrete–continuous model of relationship between “with whom” and episode start time and duration. *Transportation Research Record*, 2076, 81-87.
22) Hanemann, W.M. (1984). Discrete/continuous models of consumer demand. *Econometrica*, 52(3), 541-

561.
23) Jang, S., and Ham, S. (2009). A double-hurdle analysis of travel expenditure: Baby boomer seniors versus older seniors. *Tourism Management*, 30(3), 372-380.
24) Jara-Díaz, S. (2003). On the goods-activities technical relations in the time allocation theory. *Transportation*, 30, 245-260.
25) Joe, H. (1997). *Multivariate Models and Dependence Concepts*. Chapman and Hall/CRC.
26) Johnson, M.B. (1966). Travel Time and the Price of Leisure. *Western Economic Journal*, 4, 135-145.
27) King, R.L., and Woodside, A.G. (2001) Qualitative comparative analysis of travel and tourism purchase-consumption systems. In: J.A. Mazanec, G.I. Crouch, J.R. Brent Ritchie, and A.G. Woodside (Eds.): *Consumer Psychology of Tourism, Hospitality and Leisure*, Volume 2, 87-105, CABI Publishing.
28) Kitamura, R. (1984). A Model of Daily Time Allocation to Discretionary Out-of-Home Activities and Trips. Transportation Research Part B, 18(3), 255-266.
29) Kuwano, M., Fujiwara, A., Zhang, J., and Tsukai, M. (2011). Joint modeling of vehicle holding duration and traveling distance with a copula-based multivaiate survival model. *Asian Transport Studies*, 1(3), 303-317.
30) Lamondian, J.(2010). A Behavioral Framework for Tourism Travel Time Use and Activity Patterns. Doctor dissertation, Department of Civil, Architectural & Environmental Engineering, The University of Texas at Austin, August.
31) Lee, B.J. (1992). A nested tobit analysis for a sequentially censored regression model. *Economics Letters* 38, 269-273.
32) Lew, A., McKercher, B. (2006). Modeling Tourist Movements: A Local Destination Analysis. *Annals of Tourism Research*, 33(2), 403-423
33) Morley, C. (1992). A microeconomic theory of international tourism demand. *Annals of Tourism Research*, 19(2), 250-267.
34) Nelsen, R.B. (2006). *An Introduction to Copulas* (2nd edition), Springer-Verlag, New York.
35) Palmquist, R.B., Phanerf, D.J., Smith, K. (2010). Short Run Constrains and the Increasing Marginal Value of Time in Recreation. *Environmental and Resource Economics*, 46 (1), 19-41.
36) Pearce, D. (1988). Tourist Time-Budges. *Annals of Tourism Research*, 15, 106-121.
37) Pentland, W.E., Harvey, A.S., Lawton, M.P., and McColl, M.A. (1999) Time Use Research in the Social Sciences. Kluwer Academic / Plenum Publishers, New York.
38) Phillips, D. (2006) Quality of Life: Concept, Policy and Practice. New York, Routledge.
39) Smith, M.D. (2003) Modeling sample selection using Archimedean copula. *Econometrics Journal*, 6, 99-123.
40) Train, K.E. (2003). *Discrete Choice Methods with Simulation*, Cambridge University Press.
41) Trivedi, P.K., and Zimmer, D.M. (2007). *Copula Modeling: An Introduction for Practitioners*. Foundations and Trends in Econometrics 1(1), Now Publishers.
42) Woodside, A.G., and MacDonald, R. (1994). General system framework of customer choice processes of tourism services. In: R. Gasser, and K. Weiermair (Eds.), *Spoilt for Choice*. Kultur Verlag, Austria.
43) Woodside, A.G., and Dubelaar, C. (2002). A general theory of tourism consumption systems: A conceptual framework and an empirical exploration. *Journal of Travel Research*, 41(2), 120-132.
44) Wu, L., Zhang, J., and Fujiwara, A. (2011a). Representing tourist's time use behavior based on a multiple discrete-continuous extreme value model. *Journal of the Eastern Asia Society for Transportation Studies*, 9, 796-809.
45) Wu, L., Zhang, J., and Fujiwara, A. (2011b). Analysis of tourism participation and expenditure with a Scobit-based discrete-continuous choice model. *Tourism Management* (under review).
46) Wu, L., Zhang, J., and Fujiwara, A. (2012). Dynamic analysis of Japanese tourists' three stage choices: Tourism participation, destination choice and travel mode choice. *Transportation Research Record (in press)*.
47) Zhang, H., Zhang, J., Kuwano, M.(2012). An integrated model of tourists' time use and expenditure behavior with self-selection based on a fully-nested Archimedean copula function. *Tourism Management*, 33(6), 1562-1573.
48) Zhang, J. (2009). A model of time use and expenditure of pedestrians in city centers. In H. J. P. Timmermans (Ed.), *Pedestrian Behavior: Models, Data Collection and Applications*, 157-194, Emerald.
49) Zhang, J., Timmermans, H. J. P., and Borgers, A. (2005). A model of household task allocation and time use. *Transportation Research Part B*, 39, 81-95.

50) Zhang, J., Zhang, H., Wu, L., and Fujiwara, A. (2009). Representing tourists' context-sensitive time use and monetary consumption behavior. *Proceedings of the 15th Annual Conference, Asia Pacific Tourism Association (APTA)*, Incheon, Korea, July 9-12 (CD-ROM).
51) Zuzanek, J. (1980). Work and Leisure in the Soviet Union: A Time Budget Analysis. New York: Praeger.

[†] This paper was reproduced from a paper presented at the 92th Annual Meeting of the Transportation Research Board, Washington, D.C., January 13-17, 2013