A Trip Pattern Choice Model of Shopping Travel Based on Consideration of Flexible Daily Time Constraint

Muhammad Isran RAMLI
Doctoral Course Student
Dept. of Urban & Environment. Engineering
Kyushu University
7-4-4, Motooka, Nishi-ku, Fukuoka, 819-0395 Japan
Fax: +81-092-802-3403
E-mail: ramuri@civil.doc.kyushu-u.ac.jp

Yoshinao OEDA
Associate Professor
Dept. of Urban & Environment. Engineering
Kyushu University
7-4-4, Motooka, Nishi-ku, Fukuoka, 819-0395 Japan
Fax: +81-092-802-3403
E-mail: oeda@civil.doc.kyushu-u.ac.jp

Tomonori SUMI
Professor
Dept. of Urban & Environment. Engineering
Kyushu University
7-4-4, Motooka, Nishi-ku, Fukuoka, 819-0395 Japan
Fax: +81-092-802-3403
E-mail: sumi@doc.kyushu-u.ac.jp

Chiaki MATSUNAGA
Assistant Professor
Dept. of Urban & Environment. Engineering
Kyushu University
7-4-4, Motooka, Nishi-ku, Fukuoka, 819-0395 Japan
Fax: +81-092-802-3403
E-mail: matunaga@civil.doc.kyushu-u.ac.jp

Abstract: This paper proposes simultaneous choice model of trip pattern and departure time on one-day shopping travel that consider the availability of a flexible daily time constraint during noon until evening, namely praying time constraint. The choice model assumes that traveler’s decision to the both travel problem is determined at the same time and due to minimize the total disutility of three kinds of disutility. The three include disutility of shortage stay time at shopping place, disutility of lateness home arrival time, and disutility that consider the praying time constraint. The model was applied to the individuals who are living in a residential area and have been conducting shopping centre travel. Mostly they have to choose their departure time and trip pattern for the travel at the same time in a certain time frame, where they should conduct a praying time-activity as Islamic society. By taking a goodness of fit test, the proposed model was acceptable. The model can be applied to develop a model of travel mode choice in further studies.

Key Words: Trip pattern, shopping travel, disutility, flexible daily time constraint.

1. INTRODUCTION

Trip pattern and departure time choice of travelers on one-day travel are two of determinant factors in travel demand analysis with activity travel behavior approach, particularly in order to overcome such kind of transportation congestion problem on travel demand management (TDM). In any case, individual’s decision for the both problems is important to predict temporal demand for planning of development and construction of new transportation infrastructure. The decisions of individuals are also useful to test responses of demand in order to improving of operational strategies of traffic control or transportation measures. Other benefit of the decision is to assess the effectiveness of implementation of TDM measures on a specific time.

In concerning to one-day shopping travel where home is place basis of the trip origin-destination, at least there are commonly two kinds of trip pattern, i.e., home-shopping centre-home (H-SC-H) trip pattern and home-shopping centre-other place-home (H-SC-OP-H) trip
pattern. In this regard, individuals may decide one of the both trip patterns to be chosen before they leave their home. In other side, individuals should decide their departure time from home at the time. It means that the travelers have to decide their trip pattern and departure time simultaneously at the same time.

Recently, many researches focused on non-work trips such as shopping trip, recreation trips, etc. (see, for example, Bhat, 1998a, 1998b; Bhat and Steed, 2002; and Vovsha and Bradley, 2004; and Ramli et al., 2010d). These researchers focused on non-work trip due to the reasons such as non-work trips contribute increasingly large proportion to urban trips recently, especially on peak periods, and non-work trips have more temporal flexibility of individual than work trips. In addition, the non-work trip provides more or less congestion and some kinds of environmental problem in the centre business district, CBD of city.

Overall, almost those previous researches focused on the choices models of departure time, trip pattern, and travel mode that affected by numerous and complexity factors such as individual characteristics, attributes of work, characteristics of transportation system, and real-time information related to traffic delays. However, it is often difficult to clarify how each particular factor affects the observed result when the approach model is comprehensively used (Sumi et al., 1990). This is the one main reason why the transform capability of those models is insufficient when they are confirmed to the real world.

To overcome the weakness of the above researches, only a few studies have been conducted. For this reason, Sumi et al. (1990) began to introduce a different approach model in order to reduce the limitation of transferability of those researches. The model assumed that only time attributes of travelers due to the operational features of transit system affected traveler’s choice or decision. Basically, the approach model used marginal utility or disutility of primary time factors on one day travel, i.e. departure time, arrival time, stay time, and travel time. This approach led to utilization of threshold time of disutility which had to be avoided by individuals in order to choose their departure time from origin place or arrival time at destination place.

In this regard, specifically for non work trip which use the threshold disutility model approach, a previous study proposed a model to consider the one day life cycle for non-work trips (Sumi et al., 1994). It was expanded to take account for more short time behavior (Sumi et al., 1995), and for the travel with a series of plural destinations (Ooeda et al., 2005). The model provided a basis for taking account of excess-day travel (Ooeda et al., 1997) and for taking account of the frequency of a non-work trip (Chen et al., 2004, 2005). In the last of previous researches, the authors of the present paper proposed a choice model of departure time to a short shopping travel for certain purpose that utilized the minimizing disutility approach (Ramli et al., 2010a). The model particularly regard to daily shopping travel which consider lunch activity in around of the noon as one of flexible daily time constraints of travelers to decide their departure time. In addition, the authors also found a different time constraint, namely praying time during noon until evening as another flexible daily time constraint that affected individuals to decide their leave time from a shopping place (Ramli et al., 2010b). The new time constraint is usually occurrence on individual in Islamic society. In further, the author’s fascination with the praying time constraint led to the authors to introduce the phenomenon in development departure time choice model (Ramli et al., 2010c). The model was successful to show the constraint as instead of the lunch time constraint that affected traveler’s decision related to one-day shopping travel on the society.
In order to expand the last author’s research on effect of the praying time constraint to traveler’s decision on shopping travel that used the threshold disutility analysis approach, the present paper concern to develop a simultaneous choice model of trip pattern and departure time of travelers on one-day shopping travel, where the both choice problems are decided at a same time and consider the praying time constraint as the flexible daily time constraints.

The remainder of this paper is composed as follows. The next section presents the development of model structure. Then, Section 3 demonstrates the model application. The final section provides discussion related to the result of the model implementation and summarizes important findings.

2. DEVELOPMENT OF MODEL STRUCTURE

2.1 Flexible Daily Time Constraint and Disutility on One-Day Shopping Travel

As the authors introduced in previous researches (Ramli et al., 2010a; 2010b; 2010c), individuals of one-day shopping travel on Islamic society in mostly developing countries face praying time constraint as flexible daily time constraint to be considered to decide their time attributes of the travel. The constraint influenced traveler’s decision, not only on leave time from shopping place but also on departure time from home.

In other point of view, travel has generally been regarded as disutility. Regarding to shopping travel behavior, travelers have at least two elements of travel disutility, i.e. disutility at origin place, and disutility at activity place, particularly at shopping place. The elements of the disutility should be assessed in the time-frame of the above flexible daily time constraint due to the individuals will decide their time attributes according to the smallest disutility of total disutility which they may take.

In the previous researches (Ramli et al., 2010a; 2010b; 2010c), the authors have already introduced some types of disutility on basis H-SC-H trip pattern. The types of disutility that regard to the places where decisions are made include two types of disutility, disutility due to the earliness in morning and lateness at night. The both of disutility are assumed to express the variation of activity level is mainly dealt with origin place processes (i.e. leave home process and return home process). The others types of disutility are assumed in order to express the travelers behavior to stay enough time at the shopping place, one is that due to the shortage of stay time for expressing the behavior to have enough stay time, and that due to the length of stay time to express the stay time is not extended if people feel it enough. In further, those researches also introduce disutility of flexible daily time constraints including lunch time in the noon, and or praying time during in the afternoon through in the evening, in order to response the availability of the flexible constraints on one-day shopping travel behavior.

The functions of the all types of disutility as shown by Figure 1 are as following expressions:

\[
D_1 = \begin{cases} 
-A(t_d - t_i) & (t_d < t_i) \\
0 & (t_d \geq t_i)
\end{cases}
\]  
\( (1) \)

\[
D_2 = e^{-\alpha t}
\]  
\( (2) \)
$D_3 = \beta t_s$  \hspace{1cm} (3)

$D_4 = \begin{cases} B(t_h - t_b) & (t_h > t_b) \\ 0 & (t_h \leq t_b) \end{cases}$  \hspace{1cm} (4)

$D_5 = \frac{1}{t_{df} - t_{ds}}$  \hspace{1cm} (5)

Where:
- $D_1$: disutility of earliness home departure time on leaving home process;
- $D_2$: disutility of stay time shortness at shopping place;
- $D_3$: disutility of stay time lateness at shopping place;
- $D_4$: disutility of earliness home arrival time on returning home process;
- $D_5$: disutility of flexible daily time constraints (i.e. praying time or lunch time constraint);
- $t_{ds}$, $t_{h}$: departure time from home and arrival time at home respectively;
- $t_{h}$: the threshold time when people become not to mind the earliness departure at home;
- $t_{s}$: the threshold time when people become not to mind lateness arrive at home;
- $t_{ds}$: stay time at shopping centre;
- $t_{ds}$, $t_{df}$: start and end time of lunch activity respectively;
- $A, B, \alpha$, and $\beta$: positive parameters.

Figure 1 Total disutility of travelers on one-day shopping travel for H-SC-H trip pattern

In other side, when the individuals face commonly the other trip pattern, H-SC-OP-H trip pattern, the total disutility that will be faced by the travelers becomes more extensive and complex than the total disutility on H-SC-H trip pattern. The combination of the all types disutility for the two places, shopping place and other place, is showed in Figure 2 later.

Regarding to the purpose of the present paper, the next sub section will show the derivation of traveler’s choice model when the individuals may decide their trip pattern choice and departure time choice simultaneously at the same time. The derivation consists of two steps, i.e. derivation of departure time choice, then derivation of trip pattern choice. The minimum value of the total disutility between the both trip pattern choices which include the minimum disutility of departure time choice at the same time is main consideration of the travelers.
2.2 Departure Time Choice Model of Travel to Shopping Centre

As mentioned above, travelers face mainly two trip pattern to be chose when they will leave their home for one-day shopping travel. While at the same time, the individuals have to decide their departure time too. In order to derive the simultaneous model of the both choice problems, this section will explain the derivation of departure time choice model of the both trip patterns respectively, as the first step of the simultaneous model.

2.2.1 Departure time choice model on H-SC-H trip pattern

The derivation of the departure time choice model of individuals on H-SC-H trip pattern in this subsection follows the same way derivation of the model as regarding in the previous researches of the authors (Ramli et al., 2010a; 2010c) as below.

The departure time choice model of the H-SC-H trip pattern regard that people choose their departure time to shopping place under consideration that the decision not only on leaving time from the shopping place but also arrival time at home at a same time. This emphasizing leads to derivation of the model into two-step decision-making case. The first step is condition where threshold time to get disutility of earliness home departure time, \( t_d \), is less than optimum departure time, \( t_{d0} \), or threshold time to get disutility of lateness home arrival time, \( t_h \), is less than arrival time at home, \( t_h \). The second step is that \( t_d \) and \( t_h \) are equal or more than \( t_{d0} \) and \( t_h \) respectively. The model derivation of the departure time model as a two-step decision-making will be deduced in the next part as follows.

Firstly, regard that individuals will consider their departure time to shopping place in order to minimize all of their disutility, and with assumes all the types of utility are addable, the sum of disutility according to the places where decisions are made for the first case, \( D_{23} \), is given as a function of stay time, \( t_s \) as follows.

\[
D_{23}(t_s) = D_2(t_s) + D_3(t_s) \tag{6}
\]

Whereas the minimum of the sum disutility is given as an optimum point of stay time as below:

\[
\left. \frac{D_{23}(t_s)}{dt_s} \right|_{t_{so}} = 0 \tag{7}
\]

Because that there are following relations among the variables relating to time as below:

\[
t_i = t_s + t_a \tag{8}
\]

\[
t_a = t_d + t_n \tag{9}
\]

\[
t_h = t_n + t_l \tag{10}
\]

And assumption that total time consumption for the activity is less than the time interval from \( t_i \) and \( t_h \), the person can choose the departure time from home and arrival time at home later than \( t_i \) and earlier than \( t_h \), respectively. Hence, the distribution of departure time from home, \( \tilde{O}_{dl}(t) \), can be stated as a unit distribution as follows.
\[ \phi_{d1}(t) = \frac{1}{t_{d0} - t}, \quad (t < t_{d0}) \] (11)

Where \( t_{d0} \) is a constant value given by the following equation:

\[ t_{d0} = t_b - t_n - t_{s0} - t_n \] (12)

The second step assumes that a person cannot choose their departure time within the range \([t_t, t_{d0}]\) or \( t_t \geq t_{d0} \). It means that the individuals decide departure time also taking account of \( D_1 \) and \( D_2 \). As similar assumption with the first case, in particular that all the types of utility are addable, the total disutility in this case, \( D_{1234} \), is given as follows.

\[ D_{1234}(t) = D_1(t_d) + D_2(t_s) + D_3(t_s) + D_4(t_h) \] (13)

Regard to the relationships among the time variables in the Equations (8), (9), and (10), the Equation (13) can be restated as function of departure time, \( t_d \) as below:

\[ D_{1234}(t_d) = D_1(t_d) + D_2(t_s) + D_3(t_s) + D_4(t_h) \] (14)

Then, the optimum departure time of individual is given as follows the condition.

\[ \frac{D_{1234}(t_d)}{dt_{d}} \bigg|_{t_{d} = t_{d0}} = 0, \quad (t_t \geq t_{d0}) \] (15)

Hereafter every decision-making is shall regarded conditional on travel time and stay time in order to consider group of individuals and availability of travel time distribution.

2.2.1.1 Consideration of choice behavior dispersion
In order to represent fact in the real world that human behavior has always any dispersion, as consequently of individual and occasional differences, some parameters have to be defined as random variables. In this case, \( t_t, t_{h}, \) and \( \alpha \) are defined as random variables to express the dispersion of departure time, leaving time, and stay time respectively. Their probability density functions (PDF) are denoted by \( \Theta_{t_d}(t) \) and \( \Theta_{t_h}(t) \) respectively and their dispersion are assumed to independent each other.

Regarding the above assumptions, Equation (11) and (15) are rewritten into the following expressions.

\[ \phi_{d1}(t|\tau) = \int_{\infty}^{\infty} \int_{-\infty}^{\infty} \phi_{\tau}(\tau) \phi_{\tau}(s) d\tau ds, \quad (t < t_{d0}) \] (16)

The distribution of arrival time at destination for a given travel time, \( t_n \), is given as follows.

\[ \phi_{n3}(\tau|\tau) = \phi_{d1}(t - t_n), \quad (t < t_{d0}) \] (17)

Considering the distribution of \( \Theta_{t_d}(t) \) and \( \Theta_{t_h}(t) \), the optimum departure time given by Equation (15) provides the distribution of departure time as follows.
\[
\phi_{d2}(t|t_n) = \int \phi_{d1}(t_b) \left| \frac{dt_b}{dt_{d2}} \right| \phi_n(s) d\tau d\sigma, \quad (t \geq t_{d0}) \tag{18}
\]

Then, the distribution of arrival time at the destination is again obtained as follows.

\[
\phi_{a2}(t|t_n) = \phi_{d2}(t - t_n), \quad (t \geq t_{d0}) \tag{19}
\]

Because the both distribution above have limitation from time constrain in the parentheses, they are not PDFs in normal sense. Then, the PDF of departure and arrival time are given by the sum of the Equation (16) and (18), and the Equation (17) and (19) respectively as follows.

\[
\phi_{da}(t|t_n) = \begin{cases} 
\phi_{d1}(t|t_n), & (t < t_{d0}) \\
\phi_{d2}(t|t_n), & (t \geq t_{d0}) 
\end{cases} \tag{20}
\]

\[
\phi_{aa}(t|t_n) = \begin{cases} 
\phi_{a1}(t|t_n), & (t < t_{d0}) \\
\phi_{a2}(t|t_n), & (t \geq t_{d0}) 
\end{cases} \tag{21}
\]

In order to take account of a human group with PDF of travel time distribution, \(\Phi_{tn}(t_0)\), Equation (20) and Equation (21) can be restated as below:

\[
\phi_{da}(t) = \int_0^\infty \phi_{d1}(t|t_n) \phi_{tn}(t_n) dt_n \tag{22}
\]

\[
\phi_{aa}(t) = \int_0^\infty \phi_{a1}(t|t_n) \phi_{tn}(t_n) dt_n \tag{23}
\]

The above argument lead to a complementary calculation is possible to be done. In later, this paper will show comparing departure time distribution derived from above equation to observed departure time distribution.

2.2.1.2 Consideration of the daily praying time constraints during in the noon-evening

As purpose of this paper to introduce the availability of time constraint related to the specific flexible daily time activity, i.e. praying time activity during in the noon through in the evening, now the authors will introduce the constraint into the departure time choice model. In this regard, the constraint is treated as the flexible time constraint during noon until evening. In order to show the constraint taking into the model, lets to denote start time and time duration of the noon-evening activity as \(t_{dn}\) and \(t_{dne}\), and the distributions of these two as \(\phi_{dn}(t)\) and \(\phi_{dne}(t)\), respectively. Also the probability density function is denoted as \(\phi_{dn}(t)\). Then, the probability of that a given the noon-evening activity time, \(t_{dn}\), is included in the departure time, \(P_{dn}\), is obtained by the multiplication of the probability the activity has already started and the probability the activity is still continuing.

\[
P_{dn}(t_a) = \int_{t_a}^{t_a} \phi_{dn}(\tau) \int \phi_{d}(s) ds d\tau \tag{24}
\]
If the arrival time or departure time is included in the flexible time constraint, the distribution of departure time and arrival time is corrected as follows.

\[
\phi_{t_a}^c(t_a) = \left\{ 1 - P_{dn}(t_d) \right\} \phi_{t_a}(t_a) / \int \left\{ 1 - P_{dn}(\tau) \right\} d\tau
\]

\[
\phi_{t_d}^c(t_d) = \left\{ 1 - P_{dn}(t_a) \right\} \phi_{t_d}(t_d) / \int \left\{ 1 - P_{dn}(\tau) \right\} d\tau
\]

2.2.2 Departure time choice model on H-SC-OP-H trip pattern

Departure time choice model for the H-SC-OP-H trip pattern (hereafter, we called trip pattern-2) can be derived as continuous of disutility total from model of the trip pattern-1. As showed by Figure 2, travelers will face similar disutility when they choose a trip to other place before they return to their home. In this situation, again travelers will consider disutility of shortage and length stay time of the second place. In this pattern, let to denote \( t_{n1} \), \( t_{n2} \), and \( t_{n3} \) as travel time from home to shopping place, from shopping place to other place, and from other place to home respectively. Also we denote \( t_{s1} \) and \( t_{s2} \) as stay time at shopping place and other place.

With the same way of trip pattern-1, the disutility total of the trip pattern-2 can be stated as follows:

\[
D_{tot2}(t_d) = D_1(t_d) + D_2^1(t_d) + D_3^1(t_d) + D_4^2(t_d) + D_5^2(t_d) + D_6(t_a)
\]

Figure 2 Total disutility of travelers on one-day shopping travel for H-SC-OP-H trip pattern

In this case, there are following relations among the variables relating to time as below:

\[
t_{l1} = t_{s1} + t_{a1}
\]

\[
t_{l2} = t_{s2} + t_{a2}
\]

\[
t_{a1} = t_{a} + t_{n1}
\]

\[
t_{a2} = t_{a} + t_{n1} + t_{l1} + t_{n2}
\]
\[ t_h = t_{a1} + t_{l1} + t_{l2} \]  \hspace{1cm} (32)

Where \( t_{a1} \) and \( t_{a2} \) are arrival time at shopping place and other place, while \( t_{l1} \) and \( t_{l2} \) are leave time from shopping place and other place respectively.

With follow the assumptions of the trip pattern-1 as explained above, the distribution of departure time of trip pattern-2 can be expressed as below.

\[ \phi_{d1}^2 \left( t_{a1}, t_{a2}, t_{n3} \right) = \int \int \int \frac{1}{s} \phi_{b1}(s) \phi_{b2}(s) ds \]  \hspace{1cm} (33)

\[ \phi_{d2}^2 \left( t_{a1}, t_{a2}, t_{n3} \right) = \int \phi_h \left( t_h \right) \left( \frac{dt_h}{dt_{d2}} \right) \phi_n(s) ds \]  \hspace{1cm} (34)

Where \( t_{d0} \) is a constant value given by the following equation:

\[ t_{d0} = t_b - t_{n3} - t_{l2} - t_{a2} - t_{a1} \]  \hspace{1cm} (35)

Furthermore, Equation (20) through Equation (26) for trip pattern-1 can be applied to trip pattern-2 in term that Equation (27), Equation (33), and Equation (34) are substituted into those equations.

### 2.3 Trip Pattern Choice Model on One-Day Shopping Travel

As the second step of the derivation of the simultaneous trip pattern and departure time choice, this sub section will derive the trip pattern choice model that included the total disutility value that became primary consideration of the individual in the departure time choice model of the each trip pattern. The derivation is explained as below.

Based on the disutility minimization analysis approach, the discriminate distributions of the disutility are applied in order to deduce the trip pattern choice model. In this case, given two kinds of trip patterns as alternatives, and lets firstly to denote the traveler’s disutility in conducting trip pattern-1 and trip pattern-2 as \( D_1 \) and \( D_{12} \) respectively as showed by Figure 3.

![Figure 3 Diagram of trip pattern choice](image)

According to the assumption that traveler would choose the one with minimum disutility from the both available trip patterns, the probability of traveler to choose trip pattern-1, \( P_1 \) could be stated as follows:

\[ P_1 = P[D_1 < D_{12}] \]  \hspace{1cm} (36)
The probability $\Delta q_1(D_1)$ that traveler judges $D_1=D$ in a little $\Delta D$ section would be calculated by:

$$\Delta q_1(D_1) = \phi_{D_1}(D_1)\Delta D_1 \quad (37)$$

In the same condition, if the traveler judges $D_{12} > D$ and then decides to choose trip pattern-2, his choosing probability is given as follows:

$$\Delta P_1(D_1) = \phi_{D_1}(D_1)\Delta D_1 \int_{D_1}^{D_{12}} \phi_{D_{12}}(D_{12})dD_{12} \quad (38)$$

Thus, the choice probability of trip pattern-1 in entire scope of $D$ is determined by:

$$P_1(D_1) = \int_0^{D_1} \Delta P_1(D_1)dD_1 = \int_0^{D_1} \phi_{D_1}(D_1)\int_{D_1}^{D_{12}} \phi_{D_{12}}(D_{12})dD_{12} dD_1 \quad (39)$$

3. APPLICATION OF MODEL

The above proposed model can be applied to all travel behavior in particular on one-day shopping travel behavior, where travelers consider not only lunch time in the noon and dinner in the evening, but also praying time constraint during in the noon through in the evening as flexible daily time constraints as purpose of the present paper. Concerning to the trip pattern choice on one-day shopping travel such as H-SC-H and H-SC-OP-H trip pattern choices, the duration or time length from departure from home to arrival at home is not so short since travelers have chance to do some activities in the shopping place as variation of tenants in the place such as mini-market to buy daily goods, book shop, a movie, cafeteria, restaurants, etc. In addition to the concerning, travelers are not necessary to leave their home and their shopping place earliness for most cases of H-SC-H trip pattern, because they have only one destination place in a day. So that they have sufficient time to enjoy their travel at the shopping place. As well as H-SC-OP-H trip pattern, where people almost treat the second place, the other place (OP), as secondary place to visit only for short time, so that shopping place also become primary place for their trip. Therefore, the model can be simplified to be applied to the behavior for the both trip patterns choices. In this regarding, Equation (18) and Equation (34) do not need to be applied, so that travelers’ behavior can be expressed enough by Equation (16), Equation (17), and Equation (33) with conditioning minus disutility of the length of stay time, and also by Equation (25) that simplified to consider specific flexible daily time constraint during noon until evening. Thus, the parameters which used to represents the behavior of travelers are only $t_b$, $\alpha$, $t_{ds}$, and $t_{dd}$. The next sub sections will explain application of the simplified model.

3.1 Calculation Method to Estimate Parameters of the Model

The calculation method to estimate the model parameters that used in this research base on the higher multiple integrations have to be made repeatedly. The approach has hardly effective methods other than the simulation techniques for such situations. The method is not the procedure to find mathematical solution of integral equations, but the procedure to find a set of numerals possibly regarded as the parameters, and the calculated values surely depend on the set of assumed initial values. Therefore the method has to have some trial and error.
process to find the possible parameter values. The following method was applied for the purpose.

1) Replace the four parameter, \( t_b, \alpha, t_{d}s, \) and \( t_{d}d, \) that defined as random variable before, with their average and standard deviation values, \( \mu_{tb}, \sigma_{tb}, \mu_{\alpha}, \sigma_{\alpha}, \mu_{tds}, \sigma_{tds}, \mu_{tdd}, \) and \( \sigma_{tdd} \) respectively. Then, give the initial value for the all parameters.

2) Generate a set of large numbers of random numerals using the average and standard deviation for each the parameters.

3) Calculate the arrival time and its distribution for the both trip patterns choices by using taking one of the numerals for each parameter that conditional to a certain value of travel time. Repeat the procedure until the set of random numbers are all taken into account.

4) Repeat the step (3) for the changing values of travel time according to the observed distribution until the full range of travel time is covered.

5) Weight the departure time distribution for the two trip patterns choices by sharing with travel time and arrival time distribution, and suppose them so that the departure time distribution of the each trip pattern choice is obtained for all members of the group.

6) Compare the calculated distribution of the departure time of the each trip pattern choice with the observed one, and calculate the square difference between them.

7) Change the assumed values of the parameters in an iterative manner to reduce the square difference. In that matter a certain type of non-linear optimization programs is used to reduce the square difference.

8) Stop the calculation when the variation of the parameters become enough small and regard the assumed values as the estimated values for the parameters.

3.2 Implementation of Survey

A survey by using questionnaire based on home interview method was done at ten residential areas in Makassar City, Indonesia, the country that majority of its citizen have to conduct the daily praying time-activity during in the noon through in the evening. The residential areas consist of three residential areas in the northern part, four residential areas in the southern part, and three residential areas in the eastern part on the city. These residential areas were chosen to represent the variant of shopping travel characteristic of travelers from their residence to shopping place in the city. The people who had been living in the residential area are mostly constrained by the praying time-activity as a flexible daily time constraint on their travel decision. Travel demand of the citizens is serviced by para-transit and taxi as formal public transport and some informal public transit such as tricycle and motorcycle for transit. However, almost the people in the residential areas utilize private car and private motorcycle for their travel to shopping centre. In this regard, individuals have a specific time constraint to be considered in order to choose their trip pattern and departure time simultaneously at a same time on their shopping travel, i.e. they have to conduct the praying time-activity during noon until evening. These circumstances provide good opportunity to test the application of the model.

Table 1 shows the characteristics of the survey, and Table 2 shows the execution of the survey. Questionnaire sheets were distributed by surveyor to all the housings of each the residential area that selected based on random sampling selection. The questionnaires were issued and collected by surveyor by using home interview method. The number of respondent as representation of household in this survey is 1,490 respondents, while number of respondent which traveled to shopping centre with H-SC-H and H-SC-OP-H trip patterns choices as focus of data analysis in this research are 758 and 269 respondents respectively.
Table 1 Characteristic of respondent information in questionnaire

<table>
<thead>
<tr>
<th>Category of attribute</th>
<th>Respondent attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individually attributes</td>
<td>Sex, Age, Car ownership, Resident area, Family size</td>
</tr>
<tr>
<td>Attributes time of shopping trip pattern</td>
<td>Departure time from home, stay time at shopping place, leave time from shopping place, and arrival time at home</td>
</tr>
<tr>
<td>Others attributes of shopping trip</td>
<td>Origin and destination place of trip, mode travel, and number of trip</td>
</tr>
</tbody>
</table>

Table 2 Number of questionnaire

<table>
<thead>
<tr>
<th>Area</th>
<th>Location of survey</th>
<th>Number of Respondent</th>
<th>Number of Respondent for Trip Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>H-SC-H</td>
</tr>
<tr>
<td>A</td>
<td>Telkomas</td>
<td>41</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Bumi Tamalan area Permai</td>
<td>372</td>
<td>176</td>
</tr>
<tr>
<td></td>
<td>Dosen UNHAS</td>
<td>255</td>
<td>152</td>
</tr>
<tr>
<td>B</td>
<td>Bukit Baruga</td>
<td>57</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Perumnas Antang</td>
<td>198</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Dosen &amp; Pegawai UNHAS</td>
<td>107</td>
<td>56</td>
</tr>
<tr>
<td>C</td>
<td>Residen Alauddin Mas</td>
<td>42</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Gerhana Alauddin</td>
<td>43</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Bumi Permata Hijau</td>
<td>62</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Minasa Upa</td>
<td>313</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>1,490</strong></td>
<td><strong>758</strong></td>
</tr>
</tbody>
</table>

3.3 Results of Calculation

The estimated parameters of the model are shown in Table 3 along with the statistics showing the minimized square difference values, $R_{\text{Min}}$, and the fitness of the calculated and observed trip pattern and departure time choice simultaneously by using Kolmogorov-Smirnov (K-S) test. The distributions of departure time choice of each trip pattern choice that obtained simultaneously from the calculation are showed in Figures 4. It was revealed that the calculation reproduced the observed distributions well though the significant levels of goodness of fit by Kolmogorov-Smirnov (K-S) test reached 20% for the both choices distributions of H-SC-H and H-SC-OP-H trip pattern.

Table 3 Calculation result of parameters

<table>
<thead>
<tr>
<th>Parameters of Model</th>
<th>Values of parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu_{\alpha}$</td>
<td>-0.0819</td>
</tr>
<tr>
<td>$\sigma_{\alpha}$</td>
<td>0.1700</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.0390</td>
</tr>
<tr>
<td>$\mu_{\text{sh}}$</td>
<td>20.4981</td>
</tr>
<tr>
<td>$\sigma_{\text{sh}}$</td>
<td>3.8859</td>
</tr>
<tr>
<td>$\mu_{\text{ds}}$</td>
<td>17.2017</td>
</tr>
<tr>
<td>$\sigma_{\text{ds}}$</td>
<td>0.2635</td>
</tr>
<tr>
<td>$\mu_{\text{dd}}$</td>
<td>1.8236</td>
</tr>
<tr>
<td>$\sigma_{\text{dd}}$</td>
<td>0.2012</td>
</tr>
<tr>
<td>Number of Data</td>
<td>1,019</td>
</tr>
<tr>
<td>Square error minimum ($R^2_{\text{min}}$)</td>
<td>1917.065</td>
</tr>
<tr>
<td>Degree of freedom (df)</td>
<td>12</td>
</tr>
<tr>
<td>$\alpha$ of KS test (%)</td>
<td>20</td>
</tr>
</tbody>
</table>
a. Individual’s distribution of departure time choice that chose H-SC-H trip pattern

b. Individual’s distribution of departure time choice that chose H-SC-OP-H trip pattern

Figure 4 Comparison between calculation and observation of trip pattern and departure time

4. DISCUSSIONS AND CONCLUSIONS

4.1 Discussions

According to the calculation result that showed in Table 3 this sub section will discuss some important findings as below.

Parameters values of threshold time of home arrival time indicate that the shoppers of the both trip patterns choices have high time tolerance to arrive at their home when they return from shopping place. The values are showed by average value of the threshold time, i.e. 20.5 p.m., and standard deviation value is 3.88 hours. These values mean that the travelers on one-day shopping travel arrive at their home mostly in afternoon for the earliest to leave shopping place, while the shoppers arrive at the home in midnight for the latest to leave the place.

Furthermore, related to the parameters values of random variables of the flexible daily time constraint that introduced in this model, travelers inclined to choose their departure time after and before critical time of the time constraint. The phenomenon occurs on travelers that chose not only for the H-SC-H trip pattern, but also for the H-SC-OP-H trip pattern. According to the result, the authors can state that the model can represent the factual phenomenon regarding to the availability of the praying time-activity as flexible daily time constraint during noon-evening, where it is considered by the individuals to decide their trip pattern and departure time simultaneously. The flexible time constraint can instead of the lunch time constraint as one of primary consideration in order to choose travelers’ trip pattern and departure time.
The authors expect that this situation can be tested in further study in order to improve and complete the model which proposed in this study. Also the authors expect to use the phenomenon as a dominant factor that influenced individuals to choose their travel mode.

4.2 Conclusions
In this paper, the authors have proposed a simultaneous choice model to describe traveler’s decision on trip pattern and departure time that are decided at a same time and consider the praying time constraint as a flexible daily time constraint on one-day shopping travel. There are two trip patterns choices as alternatives of the travelers, i.e. home-shopping centre-home (H-SC-H) and home-shopping centre-other place-home (H-SC-OP-H) trip patterns. The model is derived from three processes, i.e. departure time consideration process, stay time consideration process, and return time consideration process. These considerations lead to four types of disutility, such as disutility of earliness departure from home, disutility of shortage of stay time at shopping place and or other place, and length of the stay of the place, and disutility of lateness arrival at home. In particular, the model considered a specific time constraints, i.e. praying time-activity constraint during in the noon until in the evening as a flexible daily time constraint. The constraint was considered by individuals in order to decide their trip pattern and departure time simultaneously on their shopping travel. However, the model was simplified to apply the properties of one-day shopping travel behavior, i.e. length duration of stay time and necessary to leave home earliness.

The proposed model was applied to the one-day shopping travel of individuals in ten residential areas in Makassar city, Indonesia, the country in Asian developing countries where majority of its citizen have to conduct the praying time-activity during in the noon through in the evening. It was revealed that the model and estimated parameters provided acceptable reproducibility of trip pattern and departure time choices simultaneously at the same time. Concerning with the flexible time constraint, the model can be observed in the both trip patterns choices.

In conclusion, the model with estimated parameters is to be tested further by applying to others situations, and the authors can expect that the model provides a basis to find more advanced and expanded models such as travel mode choice models.

REFERENCES