Abstract: In tourism demand analysis, the random utility model has been used to estimate data including tourists’ site selection processes. Recently, the Kuhn–Tucker model (KT), which is more consistent in relation to the utility maximization problem, has been developed. In this study, the attributes of demand analysis using KT are examined through comparison with the repeated discrete choice model. The travel data for eight sites in Nara Prefecture in Japan were used. As a result, the demands calculated using KT are (1) consistent with the observed data and (2) larger than those calculated by the repeated discrete choice model. Finally, the magnitude of the substitution effects is examined. It is concluded that Nara area has the largest substitution effect among all sites.

Key Words: tourism demand, kuhn–tucker model, substitution effect

1. INTRODUCTION

The development of various transportation modes has allowed people to visit different parts of the world. This growth in tourism influences the global economy and fosters competition among tourism sites. Tourism demand analysis, which is one of the most interesting fields of tourism economics, is also influenced by the expansion of tourism.

The basic tourism demand analysis is single site demand analysis (Fuji et al., 1985; Witt and Witt, 1995; Turner and Witt, 2001). The data on a single site (e.g., the number of visitors; cost of trip to the site) are collected, and then the demand is estimated. However, competition among tourism sites requires that the structure of estimation models include tourists’ site selection behaviors. The random utility model (hereinafter, RUM), which is based on the random utility theory (Ben-Akiva and Lerman, 1985), is one of the methods capable of estimating the data that include tourists’ site selection behavior.

RUM is modeled on the basis of an individual tourist’s behavior in selecting one site from among various sites. Therefore, basic RUM cannot capture multiple site selections such as when an individual selects Site 1 and Site 3 from among sites 1 to 8. Only a few extended models, such as those proposed by Needelman and Kealy (1995) and Parsons and Kealy (1995), can be applied to tourists’ complex and multiple site selection. However, RUM, and even its extended models, would be inadequate to perform an analysis on the substitution effect, which is that the decrement of travel cost for a site decreases the demand for other sites, due to the
inconsistency of RUM under the utility theory.

The substitution effect is one of the main issues with regard to demand analysis, especially when it is an analysis of multiple goods. Mohamed and Ghaffar (1989) analyzed the effect in a food market, whereas Altonji (1986) analyzed it in a labor market. Habibi and Rahim (2009) analyzed the international tourism demand and showed the existence of substitution effects in the tourism market. However, most of these estimation models did not include individuals’ multiple good selections despite these estimation models are the preferred model based on the utility theory in order to analyze the substitution effect accurately.

Recently, the Kuhn–Tucker Model (hereinafter KT), developed by Hanemann (1978) and Wales and Woodland (1983), has become the preferred model for analyzing different individuals’ choice patterns. KT uses the Kuhn–Tucker conditions (the utility maximization problem) directly, and thus makes it possible to estimate the data including tourists’ various patterns of site selection.

KT has been used for the recreation benefit analyses by Phaneuf and Herriges (1999), Phaneuf and Siderelis (2003), von Haefen and Phaneuf (2003), and von Haefen et al. (2004). KT has the following advantages: (1) it can capture the various demand patterns of individuals, and (2) it allows for the flexible change of income distribution.

First, the analysis of demand substitution is a major issue in demand analysis. However, the analysis of demand substitution by KT has not been extensively studied because the KT method is a relatively recent development, and there are few studies on its use for demand analysis. In addition, tourism demand analysis using KT is rare. Thus, the analysis of this study contributes to the development of tourism demand analysis.

KT is a method that uses the utility maximization problem directly in parameter estimation. Thus, the results of demand analysis are consistent with utility theory. However, this feature of demand analysis has not been examined owing to the recent development of KT for the estimation. The purposes of this paper are (1) to analyze the feature of demand calculation by KT and (2) to examine a case study on the substitution effect.

This paper used the repeated discrete choice model (hereinafter, RDC) for comparison with KT. Common to the two methods is the fact that they are constructed on the basis of the (utility) maximization problem. Both models assumed that an individual chooses a good (tourism site in this study) to maximize his or her utility. In this sense, it is meaningful to compare the two methods.

As for the differences between the two models, the nonlinear utility functional forms can be used in KT, whereas it is impossible to use the linear form in KT, as can be done in RDC. Thus, it is possible that the demand changes are influenced by nonlinearity. This feature of demand change is analyzed. On the other hand, demand changes calculated by RUM are not influenced as much owing to their linear functional form. A comparison of the two models elucidates the feature of demand analysis using KT.
As for the other difference, the analysis of the substitution effect by RDC is difficult. See equation (5) below. RDC cannot calculate the influence of the budget constraint in demand calculations. On the other hand, KT includes the budget constraint in equation (8), \( z = y - p'x \), and Step 2. Thus, the analysis of the substitution effect is performed only with KT.

The structure of this paper is as follows. RDC and KT are shown in Section 2. The data and the estimation results are described in Section 3. The demands and substitution effects are examined in Section 4. Finally, the conclusions of this study are presented in Section 5.

### 2. MODELS

#### 2.1 Repeated discrete choice model

This study applies RDC as one of the methods of RUM. RDC was developed by Feenberg and Mills (1980) and Needelman and Kealy (1995). Assume that an individual has a fixed choice occasion for a trip \( T \). In this study, \( T \) takes the value 76, which is the maximum value of an individual’s total number of visits calculated from the observed data. On each occasion, the individual is assumed to decide whether to travel to a site, and if so, which site to visit. The indirect utility function for an occasion is defined as either equation (1), if the individual decides to travel to site \( j \) on the occasion, or as equation (2), if the individual does not make a trip on the occasion. \( \varepsilon \) is the disturbance term of individual \( i \) on site \( j \), and it is assumed to have an independent Gumbel distribution.

\[
v_{ij} = \beta_i (y_i - p_j) + \beta_j q_j + \varepsilon_{ij} \\
v_{io} = \beta_i + \beta_j y_i + \beta_{jGND} GND_i + \beta_{jAGE} AGE_i + \varepsilon_{io}
\]

Here, \( y_i = Y_i / T \), where \( Y_i \) is individual \( i \)'s annual income; \( p_j \) is individual \( i \)'s travel cost for site \( j \); and \( q_j \) is site \( j \)'s characteristic. \( GND_i \) is the dummy variable on gender: 1 for male, 0 for female. \( AGE_i \) is individual \( i \)'s age; \( \beta \) is a parameter of the variables.

Finally, individual \( i \)'s log likelihood is defined as equation (3) and (4).

\[
\ln Pr_{ik} = \ln \left( \frac{\sum_{k=0}^{M} Pr_{ik} \exp(v_{ik})}{\sum_{k=0}^{M} \exp(v_{ik})} \right)
\]

In RDC, individuals’ \( x_{ij} \) are calculated from equation (5) and the observed data. The final result of \( x_{ij} \) is calculated as the mean value of \( x_{ij} \). Here, superscripted \( w \) indicates that a project is implemented for a site, and \( v_{ij} = \beta_j (y_i - p_j) + \beta_j q_j + \varepsilon_{ij} \) when \( k = j \).

\[
x_{ij} = T \cdot Pr_{ij} \cdot \exp(v_{ij}) / \sum_{k=0}^{M} \exp(v_{ik})
\]

#### 2.2 Kuhn–Tucker model

KT uses the Kuhn–Tucker conditions for both the estimation of parameters and the calculation of demands. Although several functional forms have been considered by earlier studies, this
study used the utility function (equation (6)) proposed by Phaneuf and Siderelis (2003). The Kuhn–Tucker conditions are derived as equation (7) from both the utility function and the budget constraint \( Y_i = z_i + \sum_{j=1}^{M} p_j x_{ij} \). Here, \( \theta \) is a parameter and \( z_i \) is individual \( i \)'s amount of composite goods. It is assumed that \( z_i \) is a strictly positive and deterministic value. The utility function can be expressed as:

\[
U_i = \ln(z_i) + \sum_{j=1}^{M} \Phi(h_i, \varepsilon_{ij}) \ln(x_{ij} \Psi(q_{ij}) + \theta)
\]

\[
x_{ij} \left( \frac{\Phi(h_i, \varepsilon_{ij})}{(x_{ij} + \alpha_j)} - p_j \right) = 0, \quad x_{ij} \geq 0,
\]

where \( \Psi(q_{ij}) = \exp(\beta_{ij} q_{ij}) \), \( \Phi(h_i, \varepsilon_{ij}) = \exp(\beta + \beta_{\text{GND}} G_{\text{NDS}} + \beta_{\text{AGE}} A_{\text{GE}} + \varepsilon_{ij}) \), \( \alpha_j = \theta / \Psi(q_{ij}) \).

Equations (8) and (9) are derived from equation (7) when \( x_{ij} > 0 \).

\[
x_{ij} = \left( \frac{z_i}{p_j} \right) \Phi(h_i, \varepsilon_{ij}) - \alpha_j
\]

\[
\varepsilon_{ij} = g_{ij}(\cdot) = \ln(p_j) + \ln(x_{ij} + \alpha_j) + \ln(z_i) - (\beta_{\text{L}} + \beta_{\text{GND}} G_{\text{NDS}} + \beta_{\text{AGE}} A_{\text{GE}})
\]

Assume that the disturbance terms have an independent Gumbel distribution. Let \( \omega \) be a scale parameter and \( I \) be a function such that \( I = 1 \) if \( x_{ij} > 0 \), and \( I = 0 \) if \( x_{ij} = 0 \). Individual \( i \)'s log likelihood of KT is defined as equation (10).

\[
ll_i = -\sum_{j=1}^{M} I \left( g_{ij} / \nu \right) - \sum_{j=1}^{M} \exp\left( -\left( g_{ij} / \nu \right) \right) - \sum_{j=1}^{M} I \times \ln(\nu) + \ln(\text{abs}[J_{\omega}])
\]

Here, \( J \) is the Jacobian matrix for the variable transformation, and \( \omega \) is individual \( i \)'s trip pattern. \( J \) has different components depending on \( \omega \). For example, let \( \{x_{i1}, x_{i2}, x_{i3}\} \) be an individual’s trip pattern for Site 1, Site 2, and Site 3, and assume that \( x_{i1} > 0 \), \( x_{i2} = 0 \), \( x_{i3} > 0 \). Then, \( J_{\omega} \) is defined as \( J_{\omega} \), and denotes the Jacobian matrix for the transformation from \( \{\varepsilon_{i1}, \varepsilon_{i2}, \varepsilon_{i3}\} \) to \( \{x_{i1}, x_{i2}, x_{i3}\} \). The components of \( J_{\omega} \) are calculated using equation (9).

In this study, the process of calculating demand using KT is the same as described in Phaneuf and Siderelis (2003). KT uses the bisection method for demand calculation because it cannot derive the closed forms of demand functions. Thus, demand or welfare calculations are performed using the numerical method. The calculation steps are summarized as follows.

Step 1: Sample random variables
Index \( i \) is omitted for simplicity. If \( x_{ij} > 0 \), calculate \( \varepsilon_{ij} \) using equation (9) because \( \varepsilon_{ij} = g_{ij}(\cdot) \) holds. If \( x_{ij} = 0 \), use the transected extreme value distribution bounded at \( \varepsilon_{ij} \leq g_{ij}(\cdot) \). The distribution is given by equation (11), and the calculation form is given by equation (12). Here, \( \Theta \) is randomly sampled from the uniform distribution.

\[
F(\varepsilon_{ij} \mid \varepsilon_{ij} \leq g_{ij}) = \frac{\exp(-\exp(-\varepsilon_{ij} / \nu))}{\exp(-\exp(-g_{ij} / \nu))}
\]

\[
\hat{\varepsilon}_{ij} = -\ln\left(-\ln\left(\exp\left(-\exp(-g_{ij} / \nu)\times\Theta\right)\times\nu\right)\right)
\]

Step 2: Calculation of Marshallian demands
Let superscripted \( \tau \) indicate the iterations with the initial value set as zero. Let \( z_{ij} \) be the lower
bound of $z$ with the initial value set as zero ($z_l^0 = 0$) and $z_u$ be the upper bound with the initial value set as $z_u = y$. Let $z_{\bar{l}}$ be the mean value of $z_l$ and $z_u$. Calculate demands $x_{ij}^{\bar{r}}$ under $p_j = p^*$ using equation (8) ($x_{ij}^{\bar{r}} = 0$ when $x_{ij}^{\bar{r}}$ is negative), and calculate $z$ (hereinafter $\hat{z}$) using $\hat{z} = y - px^{\bar{r}}$ (note that $y$ and $p$ are observed data).

If $\hat{z} > z_u$, then set $z_u^{\bar{r}+1} = z_u$ and $z_{\bar{l}}^{\bar{r}+1} = z_u$. If $\hat{z} < z_u$, then set $z_l^{\bar{r}+1} = z_l$ and $z_{\bar{l}}^{\bar{r}+1} = z_{\bar{l}}$. Repeat this process until $|\hat{z} - z_l| < c$. Then, $z_l$ and $x_{ij}^{\bar{r}}$ under $|\hat{z} - z_l| < c$ are the Marshallian demands at which a project is implemented.

Step 3: Repeat process
Repeat Steps 1 and 2 a sufficient number of times. The mean value of $x_{ij}^{\bar{r}}$ is the demands for site $j$ at which a project is implemented.

The sums of individual $i$’s log likelihood in the models become the log likelihood functions for the estimations. In this paper, R ver. 2.11.1 is employed for the estimations and demand calculations.

3. ESTIMATIONS

3.1 Data
In this study, individuals’ travel data for Nara Prefecture in central Japan are used for the estimation. Nara Prefecture has three world heritages (Buddhist monuments in the Horyu-ji area, historical monuments of ancient Nara, sacred sites and pilgrimage routes in the Kii Mountain Range) and several national treasures. Therefore, Nara Prefecture is one of the most popular tourist sites in Japan.

Data were collected through an Internet research company (Rakuten Research) in March 2006. The research was performed in two steps. First, the company sent an e-mail asking respondents who were already registered with the company (the total number of e-mails is a business secret of the company) whether or not they visited eight areas in Nara Prefecture in the past year. The locations of areas, site names, and number of sites are shown in Figure 1. Second, 1,000 people were invited to complete an online questionnaire, and the data on their number of visits ($i_{ijx}$), the average cost for each trip to the site ($i_{ijp}$), and their annual income ($i_{iY}$) were collected. Information on their gender ($i_{iGND}$) and age ($i_{iAGE}$) had been previously collected by the company.

In earlier studies on KT, the cost for a trip to a site was calculated using both the distance and the time from the respondent’s home to the site. However, it is difficult to measure the distance and the time in the case of trips that take long periods and cover long distances. As a feasible solution for performing empirical analysis, this study set the individuals’ unknown travel costs to be the mean value of the costs for the trips individuals made to the sites.

This study used the individuals’ preference order for sites as an alternative variable of sites’
characteristics \((q_i)\). These data were collected by asking respondents their order of preference for the eight sites. Then, points from nine to two were allocated to the sites according to the decreasing order of preferences. One point was assigned to the sites that an individual did not visit at all.

Further, data for 43 respondents were eliminated since they reported their number of visits as zero for all sites, despite responding at the first step that they had visited the eight areas; it would appear that these respondents misunderstood the questionnaires. Next, the amounts of composite goods \(\sum_{i=1}^{N_i} P_i x_i\) for 227 respondents were calculated and shown to have negative values, which is a result inconsistent with the definition of the budget constraint. Hence, these data were also eliminated since these 227 people have also possibly misunderstood the questionnaires. In addition, the setting of \(z > 0\) is a condition of KT. This condition is written in the above line of equation (6). KT cannot be used without satisfying this condition. Equation (6) also requires \(z > 0\) owing to \(\log(z)\). However, the aforementioned 227 persons’ data do not satisfy this condition. Thus, these persons’ data were eliminated. The elimination is performed owing to the condition of KT.

Finally, the remaining 730 respondents’ data were used for estimations. The basic statistics (means and standard errors) are shown in Table 1.

### 3.2 Estimation results

Table 2 shows the estimation results of the models. The columns are the same on both sides of the table. The rows show the symbols of parameters, the maximum values of log likelihood, and the number of samples (N). Note that it is difficult to compare the goodness of fit of the two models by the log likelihood ratios because the null hypotheses of the two models are different owing to \(\nu\) in equation (10).

First, the signs and statistical significances of the parameters are discussed. The sign of the constant variable \(\beta_c\) is negative in KT, and that in RDC is positive. In all models, the constant
variables were statistically significant. For $\beta_\gamma$, the signs were positive in RDC (thus, $\beta_\gamma > 0$ is consistent with the utility theory); $\beta_\gamma$ in RDC was statistically significant. The signs of $\beta_q$ were positive and statistically significant in both models. It is natural that the parameter representing individuals’ aggregated preferences order positively influences the utility of the preferences order.

The signs of $\beta_{GND}$ were positive in KT and negative in RDC. $\beta_{GND}$ in RDC was statistically significant, but the others were not. The signs of $\beta_{AGE}$ in RDC were positive but those in KT were negative, and $\beta_{AGE}$ in both models was statistically significant. Finally, $\theta$ and $\nu$ in KT were positive and statistically significant.

The first remarkable difference between the two models is the income parameter ($\beta_\gamma$). In RDC, $\beta_\gamma$ is estimated; conversely, KT is not. The influence of the income effect (budget constraint) in KT is calculated in $z_i = Y_i - \sum_{j=1}^M p_{ij}x_j$ and Step 2. The second difference is parameter $\nu$. Generally, RDC does not estimate this because $\nu = 1$ is assumed. On the other hand, KT can estimate parameter $\nu$.

### Table 1 Basic statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Site1</th>
<th>Site2</th>
<th>Site3</th>
<th>Site4</th>
<th>Site5</th>
<th>Site6</th>
<th>Site7</th>
<th>Site8</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_j$ [per past a year]</td>
<td>1.507</td>
<td>0.493</td>
<td>0.497</td>
<td>0.638</td>
<td>0.352</td>
<td>0.337</td>
<td>0.558</td>
<td>0.504</td>
</tr>
<tr>
<td>$p_j$ [yen]</td>
<td>(2.172)</td>
<td>(1.436)</td>
<td>(1.800)</td>
<td>(1.511)</td>
<td>(0.889)</td>
<td>(1.403)</td>
<td>(1.581)</td>
<td>(1.414)</td>
</tr>
<tr>
<td>$q_j$ [point]</td>
<td>7.27</td>
<td>3.76</td>
<td>3.38</td>
<td>5.97</td>
<td>3.79</td>
<td>2.79</td>
<td>4.71</td>
<td>4.16</td>
</tr>
</tbody>
</table>

Individual characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Estimates</th>
<th>p-values</th>
<th>Estimates</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y$ [yen]</td>
<td>6,784,931</td>
<td>0.5260</td>
<td>38,9726</td>
<td></td>
</tr>
<tr>
<td>$GND$</td>
<td>0.5260</td>
<td>(0.4997)</td>
<td>(0.0347)</td>
<td></td>
</tr>
<tr>
<td>$AGE$ [years]</td>
<td>38,9726</td>
<td>(0.0125)</td>
<td>(10.3449)</td>
<td></td>
</tr>
</tbody>
</table>

a) The number of samples is 730; b) the units of variables are in brackets; c) standard errors are in parentheses

### Table 2 Estimation results of KT and RDC model

<table>
<thead>
<tr>
<th></th>
<th>RDC</th>
<th>KT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimates</td>
<td>p-values</td>
<td>Estimates</td>
</tr>
<tr>
<td>$\beta_\iota$</td>
<td>5.9276</td>
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<tr>
<td></td>
<td>(0.0784)</td>
<td></td>
</tr>
<tr>
<td>$\beta_\gamma$</td>
<td>1.723x10^-4</td>
<td>0.0000</td>
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<tr>
<td></td>
<td>(0.000)</td>
<td></td>
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<tr>
<td>$\beta_q$</td>
<td>0.2875</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td>(0.0066)</td>
<td></td>
</tr>
<tr>
<td>$\beta_{GND}$</td>
<td>$-0.1081$</td>
<td>0.0018</td>
</tr>
<tr>
<td></td>
<td>(0.0347)</td>
<td></td>
</tr>
<tr>
<td>$\beta_{AGE}$</td>
<td>0.0082</td>
<td>0.0000</td>
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<tr>
<td></td>
<td>(0.0017)</td>
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</tr>
<tr>
<td>$\theta$</td>
<td></td>
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</tr>
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<td></td>
<td></td>
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</tr>
<tr>
<td>$\nu$</td>
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<td>$\text{Max.LL}$</td>
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<tr>
<td>$N$</td>
<td>730</td>
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</table>
4. DEMAND ANALYSIS

4.1 Demand analysis on price change
For demand calculation, the hypothetical policy is the reduction of the cost (price) to make a trip to a site. The reduction rates are 10%, 30%, 50%, 70%, and 90%, and the demands for each tourist site are independently calculated. Figures 2 and 3 show the demand calculated using RDC and KT, respectively, corresponding to the reduction rates. In Table 3, the values of status quo are those calculated when the reduction rate is 0%. Table 3 elucidates that the values of the demands calculated by KT are the same as in Table 1 (mean values of observed demand), but
the values of status quo calculated by RDC are slightly different. It is considered that the demands calculated by KT are more consistent with the observed data than those calculated by RDC. Moreover, the inconsistency of RDC is due to the formulation of demand. Equation (5) shows that the demands calculated by RDC are defined as probabilistic demands. On the other hand, demands calculated by KT are defined as Marshallian demands from equation (8) and Step 2.

From economic theory, the increase in the reduction rate (namely, price reduction) leads to an increase in demand in both models. Figure 2 shows that the values of demands calculated by RDC increase almost linearly with reduction rates. The demands for all sites and all reduction rates range from 0.368 to 1.363. Figure 3 shows that the values of demands calculated by KT increase almost exponentially corresponding to reduction rates. The demands for all sites and all reduction rates range from 0.337 to 18.16. As a result, it is noted that the changes in demands calculated by KT are larger than those calculated by RDC. The reason the demands calculated by KT are larger is that the calculation of demands by KT uses equation (8), which has the exponential functional form of prices; on the other hand, the calculation of demands by the RDC model uses equation (1), which has the linear form of prices.

In this section, the relationships between demands and prices calculated by RDC and KT are explained. In this study, it has been observed that the magnitude of change in demands calculated by KT is larger than that calculated by the RDC model. It is possible that unrealistic levels of demands were calculated by KT when the reduction rate was high. This is a feature of demand analysis by KT. Since it would be unrealistic to consider a 70% or 90% price reduction as a policy, the examination of substitution effects in the next section is performed with the reduction rates at low levels—10% and 30%—only.

With regard to this point, actual travel costs to Nara Prefecture are different in each respondent’s region. If a researcher should analyze the sensitivity of demand from a particular region, the researcher would simply use the region’s data only. The demand analysis can be performed by using the eliminated data from equation (7) and Step 1. However, this study used all data because the total (or standardized) effect of demand change was confirmed. Actually, there are many discount rates on travel tickets. For example, ANA’s (an airline carrier) round-trip fare from Tokyo to Kansai International Airport (the airport frequently used to travel from Tokyo to Nara) is discounted about 12% as compared with the one-way ticket and shuttle round-trip fare, which are discounted about 34% (ANA 2011). As another example, JR Central’s (a railway company) round-trip ticket from Tokyo to Nara is discounted 10% as compared with its one-way ticket (JR Central 2011). In particular, JR Central’s discount rate does not change depending on the distance between Nara and a region. Thus, 10% and 30% discount rates are the same as or are near to the actual discount rates. In this sense, 10% and 30% are appropriate values for a case study of the substitution effect.

4.2 Demand analysis on substitution effect

Let $x_{j,r}$ be the demand of site $j$ calculated using KT when the reduction rate is $r\%$. The total market is defined as $\sum x_{j,r}$, and the market share of site $j$ is defined as $x_{j,r} / \sum x_{j,r}$. Figure 4
shows the concept of the substitution effect. The status quo in Figure 4 shows the market shares of eight sites based on the values in Table 2 (the market shares are the same as those based on the values of KT’s status quo in Table 3). The largest portion of the status quo is Site 1’s share (31%). Next, it is assumed that a policy reducing the cost of travel for Site 1 by 10% is implemented (similarly, 30% indicates the policy reducing the cost of travel by 30%). The share labeled “10%” (similarly, “30%”) in Figure 4 is the market share after the policy is implemented. Site 1’s share becomes 34% owing to the 10% reduction of the trip’s cost. It is evident that Site 1’s share is the largest and it becomes larger than the status quo; on the other hand, the market shares of sites 4, 6, and 7 clearly become smaller because of the increase in Site 1’s share.

In theory, the substitution effect was expressed by equation (8) and \( z = y-p’x \). These equations indicate that the increase of travel cost to the \( j^{th} \) site leads to a decrease in the travel demand (market share in this study) for the \( i^{th} \) site. This result is consistent with ordinal utility theory. The calculation results shown in Table 4 to Table 6 are consistent with this theory.

It is an efficient way to introduce hypothetical policies to the analysis in order to make the influence of substitution effects clear. The first hypothetical policy is that the price reduction (10% or 30% reduction) is implemented for only one site. Table 4 shows the substitution effects when the policy is implemented. The status quo \( (s_j) \) shows the values of demands in Table 2. The rows labeled 10% and 30% in the status quo column are the price reduction rate policies. The elements shaded gray in Table 4 indicate the object (site) for each policy (10% and 30% reduction). For example, the value 1.7200 in Site 1’s column and 10% row is the value of Site 1’s demand after the policy of 10% reduction is implemented for Site 1’s price, and the value 0.4927 in Site 2’s column and 10% row is the value of Site 2’s demand after the policy is implemented for Site 1’s price. As a result, the values of demands, excluding those of the site that is the object of the policy, decrease because of the substitution effect. For example, Site 2’s demand in the status quo (0.4932) decreases to 0.4927 owing to the 10% reduction in Site 1’s price, and Site 2’s demand in the status quo (0.4932) decreases to 0.4913 owing to the 30% reduction in Site 1’s price.

Table 4 shows that only the demand for a site in which a price reduction policy is implemented increases, while the demand for the other sites decreases. Here, let us consider the policies
based on the two different criteria in order to examine the substitution effect in more detail. First, the policy (hereinafter, Policy I) is implemented on the basis of the maximum total demand. That is, the policy of increasing total demand for eight sites is adopted. Second, the policy of minimizing the total substitution effect is adopted (hereinafter, Policy II). The substitution effect has negative effects for sites that are not the object of the policy. Therefore, the second policy aims to minimize the amount of negative effect in the range so that the total demand is positive. These negative effects are calculated simply as $x_{r,j} - s_{j}$.

Table 5 shows the total demand and the sum of negative effects (sum of $x_{r,j} - s_{j}$) for all sites. In the total demand of Policy I, 5.0968 at the row of 10% and the column of Site 1 means that the sum of all demands in Table 4, which are values at the row of 10% reduction rate when Site 1’s demand changes. In the sum of negative effects of Policy II, -0.0028 at the row of 10% and the column of Site 1 means that the total amount of decrement of other sites’ demand caused by Site 1’s demand change.

For Policy I, the maximum value of 10% and 30% reduction are the values of Site 1. Thus, the result of total demands in Table 5 indicates that the policies of 10% and 30% reduction should be adopted for Site 1 (Nara area) if a policy maker should implement a project for the site. For Policy II, the minimum value of 10% and 30% reduction are the values of Site 5. This means...
that the policy for Site 5 has little negative influence on other sites. The result of the sums of the negative effects in Table 5 indicates that the policies of 10% and 30% reduction should be adopted for Site 5 (Haseji-Murou area).

From these results, the most important point demonstrated by the analysis is that KT indicates that the substitution effect caused by a price policy for one site influences the demand for other sites. Thus, the second hypothetical policy is implementing the reduction rates of 10% and 30% for the prices of all sites. Table 6 shows the result of the calculations. For example, 1.7180 at the row of 10% and the column of Site 1 in Table 6 means that the demand for Site 1 after implementing a 10% price reduction for travel costs of all sites.

All of the demands at 10% and 30% reduction rates increase as compared with the status quo in Table 4. With the substitution effect functioning, however, increase in demand for sites is lower than in the former cases (the price policy of 10% or 30% reduction for a single site in Table 4). For example, Site 1’s demand increases from 1.507 to 1.7200 owing to the price policy of 10% reduction for Site 1 (Table 4), but Site 1’s demand increases from 1.507 to 1.7180 owing to the price policy of 10% reduction for all sites (Table 6). This tendency is confirmed in the changes of demands for all sites. On the other hand, as compared with the status quo in Table 4, no site has decreased demand owing to the substitution effect. As a result, it can be stated that the total demands increase to a greater extent by the all-sites price reduction policy than by the single-site price reduction policy.

5. CONCLUSIONS

The development of various modes of transportation has allowed tourists to visit different sites. This complicates the tourists’ site selection process. In tourism demand analysis, RUM has been used to solve this problem. However, the basic theory of RUM is formulated by assuming that one tourist selects one site among various sites. Thus, it is difficult to estimate on the basis of data that include tourists’ various patterns of site selection. The current study performed demand analyses by KT. KT is consistent with the utility maximization problem, and it can perform estimations on the basis of data including various patterns of site selection.
In this study, the trip data for eight sites in Nara Prefecture in Japan were used for the estimation. The demand analysis was performed by comparing KT with RDC. The hypothetical policy to improve tourism demand was to reduce the costs of trips to the sites.

First, the attributes of demand analysis using KT were examined. We found that the demands calculated using KT without the price change are equal to the mean values of the observed demands. This indicated that the demand calculation by KT was consistent with the observed data. Further, it was found that the amount of demand calculated by KT was larger than that calculated by the RDC model. In addition, the demands calculated by KT were found to increase almost exponentially with price changes, but those calculated by RDC increased almost linearly. Furthermore, these analyses indicated that the demands calculated by KT increased with larger price decrements.

Second, we analyzed the substitution effect. This analysis was performed under two hypothetical policies. The first policy was to reduce the trip cost for only one site. The reduction in trip cost increases the demand for that site, but decreases the demand for other sites that are not objects of the policy. The site that has the largest substitution effect is Nara area, and the site that has the smallest substitution effect is Haseji-Murou area. The former results indicate that a policy maker should implement a price policy for Nara area if the policy of increasing total demand for eight sites is adopted as a criterion. The latter result indicates that a policy maker should implement a price policy for Haseji-Murou area if the policy of minimizing the total substitution effect is adopted as a criterion.

The second policy was to reduce the costs of trips for all sites. As a result, the demand for all sites increased, and the increase in total demands was larger than that under the first policy, although the increases in individual site demand were lower than those after the implementation of the first policy.

This study demonstrates the attributes of demand analysis using KT. A noteworthy aspect of analyzing the demand by KT is the exponential change of the demand function. Otherwise, the calculation of demand by KT is able to capture the substitution effect accurately. Hence, it is concluded that KT is a desirable method for analysis based on the utility theoretical approach.

REFERENCES


