User Preference Survey for ITS Technology
Applied to a New Railway

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1 INTRODUCTION

Reduction of car usage and promotion of public transport use are necessary to alleviate traffic congestion, environmental problems and to reduce traffic accidents. Travel Demand Management (TDM) measures that promote the shift from car use to public transportation are considered important for reducing car traffic demand. Since cars offer the flexibility of use anytime and anywhere, people are reluctant to use public transportation. So it is important to make public transportation more attractive and more convenient to use to encourage car users to shift.

Recently, ITS technology has been focused to promote the use of public transport and to improve safety and the environment. In this paper we examine the effects of ITS technology to increase the number of passengers of the Tsukuba Express, a new rail line connecting Tsukuba City and Central Tokyo.

To promote the use of public transportation with ITS technology, it is necessary to understand user preferences. But in Japan or in the region where the Tsukuba Express is being constructed, user preferences have not yet been explained. So this research aims to analyze stated preference for ITS technology, to estimate travel demand for the Tsukuba Express with new service with ITS technology and to analyze travel behavior.

The provision of support infrastructure facilities for Tsukuba Express seems to be effective to promote the use of the new line. To estimate the magnitude of these effects we conducted the stated preference (SP) survey to get the choice data on fares, station layout and station support facilities as well as individual information and present travel behaviors of the respondents.

This study attempts to analyze the following:

1. Travel behavior characteristics of current railway and highway bus users.
   At present, the Joban Line (a commuter rail line) and Joban Highway Bus are available for Tokyo-bound trips. Analyzing the travel characteristics of the users of these modes will provide information on the potential users of Tsukuba Express. We study characteristics such as line-haul choice, station choice, access mode choice, etc. and we analyze the factors that influence travel choice.

2. Factors influencing preference to switch to Tsukuba Express.
   We analyze the factors that may influence users to switch to Tsukuba Express when it opens. From the result of this analysis, we estimate the demand for Tsukuba Express in
the area around Tsukuba. Then we get basic information that will be useful for determining the urban and transportation infrastructures that will accompany the construction of Tsukuba Express.

3. Factors influencing preference for ITS technology applied to the new line
   We analyze user preference for ITS technology that will be applied to Tsukuba Express.

2 THE TSUKUBA EXPRESS AND THE AREA AROUND TSUKUBA

This chapter describes the Tsukuba Express, Joban Line, Joban Highway Bus, and the area around Tsukuba City. Tsukuba Express is currently under construction. Joban line and Joban Highway Bus are in operation.

By the way, the commuters’ demand should be significant for these analyses. But number of the commuter demand by car transport between Tsukuba City and Tokyo central Area is a few (The share is almost 6%). In this paper, we focus on the commuter demand by Railway and Highway bus.

2.1 Description of Study Area

The south area of Ibaraki Prefecture in Japan is the study area. This area is about 40km–60km northwest of central Tokyo. Tsukuba Express is a heavy rail line being constructed to connect Tokyo and Tsukuba. Figure 1 shows the location of the study area.

Figure 1 - Location of the South Area of Ibaraki
Ibaraki Prefecture has a population of 2,985,424 based on the census of October 2000. The south area has a population of 977,126. Population of Ibaraki Prefecture has been increasing since the middle of 1950’s. In particular, the population of the south area is remarkably increasing in recent years because it has become a commuting area for Tokyo and because of the Tsukuba Science City development.

2.2 Description of Existing Public Transport Modes

2.2.1 Joban line

Joban Line is currently the only one railway line through this area. This rail line is the main artery between Ibaraki and Tokyo and well used by the workers and students living in Ibaraki and walking and studying in Tokyo and Chiba. Since this demand is concentrated to Joban Line, it is congested very much (congestion ratio \(1\) is 202\% as of 1998.)

2.2.1 Joban Highway Bus

The Joban highway bus named “Tsukuba Gou” is one of the most important modes for Tsukuba Science City. Operations started in April 1987. The number of users has been increasing rapidly since the start. This line has one of the highest frequencies among highway bus lines in Japan.

2.3 The Tsukuba Express

Tsukuba Express is scheduled to open in 2005. It aims not only to expand the transportation network by building a new line but also to reinvigorate activities along the railroad line and supply housing sites. “Tsukuba Express Project” is a significant project to achieve these purposes. In 1985, the National Transportation Policy Council identified the Tsukuba Express as an urgent measure not only to reduce congestions in Joban Line but also to provide the new residential areas along the new line.

For this purpose the “Special Measures Law for the Promotion of Integrated Housing and Railway Development” was set in force.

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1 Congestion Ratio = (number of passengers / capacity) * 100. Capacity consists of seats and standing space.
Tsukuba Express is a comprehensive project that is guided by the following basic concepts:
1. Construction of a transportation system in an area northeast of Tokyo.
2. Easing of congestion in the existing Joban Line of JR (Japan Railways)
3. Supplying residential land for the Metropolitan area.
4. Developing industrial areas and forming core business cities along the railway line

Tsukuba Express is from Akihabara in central Tokyo to Tsukuba City through the northwest area of Chiba Prefecture. It is located parallel and west of the existing JR Joban Line. The length of this line is 58.3 km and travel time from Akihabara to Tokyo will be 45 minutes. This travel time is shorter than for cities located at the same distance from Tokyo using Joban Line. Maximum speed is designed at 130 km per hour. Frequency will be high between Misato and Akihabara. Maximum peak hour frequency is set at 24 trains. From Akihabara to Tsukuba, maximum frequency is set at 4~6 trains per peak hour. Fare is from 1,100 yen to 1,400 yen according to the company that manages Tsukuba Express.

3 QUESTIONNAIRE SURVEYS TO THE JOBAN LINE AND JOBAN HIGHWAY BUS USERS

3.1 Outline of the Survey

Demand forecast for Tsukuba Express was done by Ibaraki Prefectural Government and the Housing and Urban Development Corporation (HUDC). It was mainly based on RP data survey, person-trip survey, and other data collected. But the existing data are not sufficient to
grasp detailed individual choice factors. Moreover, the collection of data to understand the potential use for ITS technology has not been done because the detail level of service of Tsukuba Express is not set up. So it is difficult to know the demand for Tsukuba Express. In this regard, travel behavior investigation using Questionnaire Survey applying Revealed Preference (RP) technique and Stated Preference (SP) technique is done in this research to understand individual preferences. Contents of the survey are shown in the Table 1.

In the part of user stated preference to ITS, we present the change of level of service, the merits and image illustration of the system to make respondents being able to image the situation that is applied ITS. Willingness to pay is the value that respondents feel while using the system with considering the merits.

Table 1 - The contents of the questionnaire investigation

<table>
<thead>
<tr>
<th>Present Travel Conditions</th>
<th>Tokyo-bound and Tsukuba-bound Trips (Transport mode, access mode, station used).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intention to use Tsukuba Express</td>
<td>Behavior change after Tsukuba Express opening (Transport mode, access mode, access station) For the service level of Tsukuba Express, more than one scenario is presented.</td>
</tr>
<tr>
<td>User stated preference to ITS</td>
<td>Presentation of the advanced technology, possibility of use, and willingness to pay Examples: automatic parking lot guidance system, seat reservation system, highway bus time forecast.</td>
</tr>
<tr>
<td>User attributes</td>
<td>Age, sex, etc.</td>
</tr>
</tbody>
</table>

The choice-based sampling was employed considering the efficiency of the survey. This survey targeted the users of Joban line and Joban highway bus since they might have the high possibility to use Tsukuba Express in the future. The questionnaire survey is described in Table 2. Figure 3 shows the location of questionnaire distribution and collection stations.

Table 2 - Survey Method and Rate of Response

<table>
<thead>
<tr>
<th></th>
<th>Joban Line User Survey</th>
<th>Joban Highway Bus User Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date and time of survey</td>
<td>9 December 1999</td>
<td>9 December 1999</td>
</tr>
<tr>
<td></td>
<td>From 8:00 AM to the last train</td>
<td>From 7:00 AM to the last bus</td>
</tr>
</tbody>
</table>
| Method of distribution and collection of questionnaires | • Hand out questionnaires to alighting users at train stations in the Tsukuba, Tsuchiura, Ushiku regions  
• Collect questionnaires by mail | • Hand out questionnaires to bus users boarding at the Tokyo bus terminal.  
• User fills out questionnaire in the bus.  
• Collect at bus stops when they alight |
| Number of collected questionnaires, (Total distributed, Collection Rate) | 699 (3,314, 21.1%) | 1,336 (1,549, 86.2%) |
|                                   | 2,035 (4,863, 41.8%)   |                               |
| Number of valid questionnaires (% of total distributed questionnaires) | 520 (15.7%) | 525 (39.3%) |
|                                   | 1045 (21.5%)           |                               |
3.2 Respondents’ Attributes

The following graphs show the characteristics of questionnaire respondents. Figure 4 shows the gender share for each mode. Figure 5 shows the age distribution. About 90% of all respondents are in their 20s to 50s. These generations have a very high share.
Figure 6 shows the distribution of jobs of respondents. 53% or more than half of them are office workers. As a characteristic of Tsukuba Science City, public servants and students have comparatively high shares.

Driver’s license ownership among samples is 87.2%. 82.2% out of licensed respondents have their own cards. Figure 7 shows the frequency of driving for car-owning respondents. 40% of them drive their car nearly everyday. Over 75% drive more than once a week. The access transport by car such as Park & Ride (P&R) and Kiss and Ride (K&R) is very important in this area.

4 CLALIFICATION OF INFLUENCING FACTORS OF TRAVEL BEHAVIOR

4.1 Four Categories of Travel Pattern

This chapter describes the mode choice of respondents for trips going to and from Tokyo. The focus is on trips from the Tsukuba area to Tokyo.

Since our samples were collected with choice-based sampling technique, railway passengers at railway stations and bus passengers at bus stops respectively, the railway share and the highway bus share of our samples were different from those in the population, the whole public transportation passengers between Tsukuba and the Tokyo. Unless we take this into account, the results would be biased.
We set the four categories for different trip patterns (Table-3). Figure 8 shows the distribution for the three categories. 41 respondents use unknown modes at least in Tokyo-bound or Tsukuba area-bound trips and they can’t be categorized. Category 4 has 3 samples and was omitted because of its small size.

![Figure 8 – Categories that we set and number of respondents of each categories.](image)

Table 3 - Categories of Respondents

<table>
<thead>
<tr>
<th>Tsukuba Area-bound trips</th>
<th>Tokyo-bound trips</th>
<th>Joban line</th>
<th>Joban highway bus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Joban line</td>
<td>Category 1</td>
<td>Category 3</td>
</tr>
<tr>
<td></td>
<td>Joban highway bus</td>
<td>Category 4</td>
<td>Category 2</td>
</tr>
</tbody>
</table>

4.2 Factors for Switching to Tsukuba Express

4.2.1 Effects of Access Distance to Tsukuba Express Stations

As a factor for switching to Tsukuba Express, access distance is considered most effective since people usually use the nearest station. Figure 9 shows switching ratio access distance to Tsukuba Express station. Switching ratio of each category is defined as the percentage of samples that expressed their desire for using Tsukuba Express on the SP question to the total number of samples. Access distance for each sample is the distance from their starting places to the station that sample answered if he or she uses Tsukuba Express.

For category 1, switching ratio is a decreasing function of access distance. For access
distance between 0 km and 2 km, the switching ratio is 67.7%. People near a Tsukuba Express station and now using Joban line may easily switch their choice to Tsukuba Express. For access distance between 2 km and 5 km, switching ratio is 45.9%. For access distance over 5 km, switching ratio abruptly decreases. For this distance range, current Joban line users mainly live along Joban line and is anticipated to continuously use it.

For category 2, the relationship between the switching ratio and the access distance is not clear. A high switching ratio is observed except for access distance of 5 km to 10 km. Tsukuba station of Tsukuba Express and Tsukuba Center bus stop of Joban highway bus are located in the same place. For the bus users who answered that they would choose Tsukuba Express, access distance to the Tsukuba Center is same. So they will get higher punctuality and reduction of time by switching to Tsukuba Express. Based on this situation, a high switching ratio is apparent.

For category 3, similar to category 1, switching ratio is also decreasing as access distance increases. Generally speaking it has a higher switching ratio than that of category 1. From 0 km to 5 km, the pattern of switching ratio is similar to category 2. Over 5 km, it is similar to category 1. People who belong to category 3 are not almost all fixed Joban line users. In Tsukuba-bound trip, they choose Joban line and Joban highway bus as occasion may demand. In the case of Tokyo-bound trips, they choose without restraints. For this reason, people near Tsukuba Express station tend to switch and people far away Tsukuba Express tend not to switch.

Figure 9 - Switching ratio with access distance
4.2.2 Effects of Access Time to Tsukuba Express Stations

Access time is defined as the time to reach a Tsukuba Express station by the access mode that they answered in the SP question.

Figure 10 shows the switching ratio by access time. Category 1 shows a tendency similar to access distance. On the other hand, category 2 and category 3 do not show a clear relation between switching ratio and access time. Switching ratio remains high even if access time increases. People who can use the Joban highway bus highly prefer to switch to Tsukuba Express.

![Figure 10 - Switching ratio with access time](image)

4.2.3 Effects of Change in Total Cost of Trip

Travel cost is generally one of the factors considered by people when they travel. Figure 11 shows switching ratio of category 1. The cost when they use Tsukuba Express is generally higher than when they use Joban line because the fare of Tsukuba Express is higher than that of Joban line. This switching ratio tends to drop as the amount of cost increase rises.

Figure 12 shows the switching ratio of category 2. The additional cost of switching from Joban highway bus to Tsukuba Express is small because the fare of Joban highway bus and expected fare of Tsukuba Express are similar. The relation between switching ratio and cost increase does not seem to exist. A weak relation that switching ratio drops as cost increases by over 120 yen is observed.

Figure 13 shows the switching ratio of category 3. A clear relation between increasing cost
and switching ratio is not observed. Switching ratio is high although cost increases. People belonging to category 3 prefer Tsukuba Express even if their total trip cost is higher.

4.3 Provisional Estimates of Demand for Tsukuba Express

We carried out provisional estimates to approximate the demand that is shifted from current public transport users to Tsukuba Express. The data we used is SP data, which were obtained from questions on the assumption that Tsukuba Express starts operations. This SP data consists of two parts. One is a choice in the situation of higher fare for Tsukuba Express. The other is a choice in the situation of lower fare for Tsukuba Express. From one respondent two SP samples were obtained. We expanded the samples to represent the data universe of all public transportation users who go to Tokyo. Universe of samples is Tokyo Metropolitan Person Trip Survey data (following PT data). Expansion factors are for trip generation zones and currently used modes. Tabulated PT data trip from Tsukuba area to Tokyo is showed in Table 4.
Table 4 - existing number of users (PT data)

<table>
<thead>
<tr>
<th></th>
<th>By rail (Joban line)</th>
<th>By bus (Joban Highway bus)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip</td>
<td>53,189</td>
<td>1,292</td>
</tr>
</tbody>
</table>

The method of estimation is as follows:

1. Calculate the switching ratio of each trip generation zone from all samples.
2. Multiply PT data by the switching ratio and sum them up. The sum represents the estimated demand.

Estimated demand is shown in Table 5.

Table 5 - Provisional estimated demand of Tsukuba Express

<table>
<thead>
<tr>
<th>Demand for Tsukuba Express</th>
<th>From Joban line</th>
<th>From Joban Highway Bus</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6,936</td>
<td>801</td>
<td>7,737</td>
</tr>
</tbody>
</table>

4.4 Willingness to Pay for ITS

Willingness to pay (following, we call WTP) for ITS was obtained by SP investigation on the assumption that ITS technology is applied to Tsukuba Express. This analysis has not been done before. We obtained the output using ratios and demand with fare based on WTP of the respondents. The total demand for the case when ITS is “Not introduced” (as shown in Figures 15 and 17) is different from the total demand in Table 5. This is because in the ITS question, the service level of Tsukuba Express is assumed with higher fare only (described in 4.3). The method of expansion is the same as in Section 4.3.

4.4.1 Automatic Parking Lot Guidance System

Katsuragi station is the second station of Tsukuba Express coming from Tsukuba Center. A policy for providing facilities for P&R users at Katsuragi station is now being considered. Figure 14 shows the estimated demand and use ratio of automatic parking lot guidance system as a function of fare (yen / time) at the Tsukuba Express Katsuragi station. Use ratio is defined as the percentage of ITS users to total number of users using public transportation for trips to Tokyo. Big changes exist between 500 yen and 750 yen, between 1000 yen and 1250 yen, and between 1500 and 1750 yen. This is because the respondents find it convenient to pay these amounts with exact change, such as using one or two 500-yen coins,
one 1000-yen bill, or their combination. When the fare is over 1000 yen, demand drastically drops since fares for existing P&R parking of the Joban line is between 600 yen to 1000 yen. People resist having to pay more than existing fares. But even for 1250 yen to 1500 yen, over 1000 people prefer to use this system. For over 1750 yen, there is almost no user.

Figure 14 - The demand and using ratio of automatic parking lot guidance system

Figure 15 shows the change in total demand for Tsukuba Express as the fare for ITS parking system changes. ITS users at Katsuragi station are considered. When the fare decreases from 1500 yen to 1000 yen, the total demand increases and about 500 people switch to Tsukuba Express to use this system. When the fare decreases to less 1000 yen, total demand increases by a small quantity. On the other hand, demand for ITS increases since people who originally prefer to use Tsukuba Express use this system. The same amount of decrease in the fare for this system causes other mode users to switch to the Tsukuba Express. When the fare greatly decreases, this system improves the user convenience of Tsukuba Express.

Figure 15 - Total and ITS demand with the fare of automatic parking system
4.4.2 Seat Reservation System

This system can be accessed from home computers or other communication modes. People reserve seats without going to the stations. This system is not obligatory for all Tsukuba Express users. This system is considered to improve user convenience by ensuring seats for users. Users can reserve the seat even if they get on at any Tsukuba Express stations. This system seems to increase Tsukuba Express users regardless of which station they use.

Figure 16 shows the demand and using ratio of seat reservation system for Tsukuba Express. Big changes exist between 300 yen and 400 yen and between 500 yen and 600 yen. When the fare is over 500 yen, the demand is low.

Figure 17 shows the change in total demand of Tsukuba Express and ITS demand. ITS users consist of two groups. One group is the users switching from other modes to Tsukuba Express when ITS is introduced. The other group is the users who prefer to use Tsukuba Express even when ITS is not introduced. Total demand of Tsukuba Express increases by about 1300 trips when the fare is 300 yen. When the fare decreases from 300 yen to 0, the increase in total demand amount is small. This system improves the convenience of Tsukuba Express users rather than increases the total demand for Tsukuba Express.
5 MODEL ANALYSIS OF AUTOMATIC PARKING LOT GUIDANCE SYSTEM

5.1 Analysis Method

In this research, we verified the effect of ITS for the Tsukuba Express. An automatic parking lot guidance system is considered for this analysis. This is because P&R is a very popular access method in the area and measures to make a convenient P&R access seems to be very promising.

The hypothesis of this analysis is that if the service level of access to Katsuragi Station is the same, the preference for Katsuragi Station Choice without ITS (without-ITS type sample is defined as “SP1”) will be different from the case with ITS (with-ITS type sample is defined as “SP2”). Preference for SP1 should be higher than that for SP2.

We developed an access mode choice model and station choice model by Nested Logit Model (Fig 18). The probability of choosing access to Katsuragi Station for SP1 was compared with that for SP2. We assumed that the probability for SP2 is higher than that for SP1 at the same level of service that includes the price of parking at Katsuragi Station.

![Diagram of Choice Structure](image)

Figure 18 – Structure of Choice

5.2 Model Structure and Estimation Results

The model we use is a Logit Model. The station choice model uses WESML (weighted exogenous sample maximum likelihood estimator) parameter consideration to Choice-Based-Sampling: investigated at every station and bus stop. For the WESML estimation, likelihood function is described by

\[
L^*(\theta) = \sum_{g=1}^{G} \sum_{i=1}^{N_g} \sum_{A_v} \delta_{in} w(g) \ln P\left(\left|X_{in}, \theta\right) \right)
\]  

(1)
where

\[ L^*(\theta) = \text{likelihood for every parameters: } \theta, \]
\[ \delta_{in} = 1 \text{ if sample } n \text{ choose station } i; 0 \text{ otherwise,} \]
\[ w(g) = \text{weight of every sampled group: } g, \]
\[ P = \text{probability for sample } n \text{ to choose station } i, \]
\[ G = \text{the number of sampled group}, \]
\[ N_g = \text{the number of samples that belong to every group: } g, \]
\[ A_n = \text{choice set for every sample } n, \]
\[ X_n = \text{factors of choices of station } i \text{ for sample } n \text{ such as specific characters and socio-economic attributes}, \]
\[ Q(g) = \text{existing ratio of group } g \text{ in the universe and} \]
\[ H(g) = \text{ratio of group } g \text{ in the samples}. \]

We constructed models of RP, SP1 and SP2 for every sample. RP model is build to representation the current choice of station. In the RP model, we utilized respondents that currently use the Joban line. The choice set for the RP model includes the Joban Line stations of Tsuchiura, Arakawaoki, Hitachinoushiku and Ushiku. In the SP1 model we use samples that use Joban Line and Joban Highway Bus that have a preference to use Tsukuba Express. In the SP2 model we use samples expanded eight-fold based on the respondents’ WTP to use WTP data in logit model. Every SP2 sample considers the cost of parking at Katsuragi from 250 yen to 2000 yen at 250 yen intervals. The expanded sample that has a price lower than the WTP price of the original sample is set up using Katsuragi ITS parking. The choice set for the SP1 and the SP2 model includes Joban Line stations and Tsukuba Express stations of Tsukuba, Katsuragi, Shimana and Kayamaru. The choice set for all access mode choice model is P&R, K&R, route bus, taxi, walking, and cycle.

Table 6 shows the parameter estimation results for access mode choice. Log-likelihood ratio of RP and SP1 are not very high. All parameters are significant based on their t-values.

Table 7 shows the parameter estimation results for station choice. Accessibility is the log-sum value for every station calculation using the access mode choice model. There is a problem in the parameter of accessibility, but the Log-likelihood ratio is very high. Reproducibility of this condition seems to be high.
Table 6 - Parameter Estimation Results for Access Mode Choice

<table>
<thead>
<tr>
<th></th>
<th>RP</th>
<th>SP1</th>
<th>SP2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fare [1000Yen]</td>
<td>-0.2525</td>
<td>-0.3842</td>
<td>-0.5557</td>
</tr>
<tr>
<td></td>
<td>(-2.85)</td>
<td>(-3.82)</td>
<td>(-13.7)</td>
</tr>
<tr>
<td>Access Time (commuter) [minutes]</td>
<td>-0.05580</td>
<td>-0.06019</td>
<td>-0.09040</td>
</tr>
<tr>
<td></td>
<td>(-6.66)</td>
<td>(-8.01)</td>
<td>(-25.1)</td>
</tr>
<tr>
<td>Access Time (business) [minutes]</td>
<td>-0.3165</td>
<td>-0.02181</td>
<td>-0.05476</td>
</tr>
<tr>
<td></td>
<td>(-4.99)</td>
<td>(-4.33)</td>
<td>(-14.1)</td>
</tr>
<tr>
<td>Access Time (private) [minutes]</td>
<td>-0.04164</td>
<td>-0.04995</td>
<td>-0.08197</td>
</tr>
<tr>
<td></td>
<td>(-2.79)</td>
<td>(-3.44)</td>
<td>(-12.1)</td>
</tr>
<tr>
<td>Dummy (P&amp;R: vehicle owner)</td>
<td>0.5263</td>
<td>1.005</td>
<td>1.721</td>
</tr>
<tr>
<td></td>
<td>(3.28)</td>
<td>(5.02)</td>
<td>(23.2)</td>
</tr>
<tr>
<td>Constant (walk)</td>
<td>1.339</td>
<td>1.487</td>
<td>1.771</td>
</tr>
<tr>
<td></td>
<td>(7.42)</td>
<td>(11.0)</td>
<td>(33.6)</td>
</tr>
<tr>
<td>Log-likelihood Ratio</td>
<td>0.11</td>
<td>0.12</td>
<td>0.22</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>412</td>
<td>518</td>
<td>3904</td>
</tr>
</tbody>
</table>

*():t-value

Table 7 - Parameter Estimation Results for Station Choice

<table>
<thead>
<tr>
<th></th>
<th>RP</th>
<th>SP1</th>
<th>SP2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility</td>
<td>7.205</td>
<td>4.368</td>
<td>2.948</td>
</tr>
<tr>
<td></td>
<td>(11.8)</td>
<td>(19.1)</td>
<td>(56.2)</td>
</tr>
<tr>
<td>Fare [1000Yen]</td>
<td>-0.4407</td>
<td>-1.888</td>
<td>-0.5583</td>
</tr>
<tr>
<td></td>
<td>(-0.30)</td>
<td>(-4.24)</td>
<td>(4.22)</td>
</tr>
<tr>
<td>Travel Time [minutes]</td>
<td>-0.01204</td>
<td>-0.02575</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-1.27)</td>
<td>(-8.38)</td>
<td></td>
</tr>
<tr>
<td>Dummy (express St.)</td>
<td>3.428</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(10.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dummy (first St.)</td>
<td></td>
<td>1.758</td>
<td>1.749</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(8.97)</td>
<td>(31.0)</td>
</tr>
<tr>
<td>Dummy (unknown St.)</td>
<td></td>
<td>-0.6815</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-1.64)</td>
<td></td>
</tr>
<tr>
<td>Log-likelihood Ratio</td>
<td>0.69</td>
<td>0.70</td>
<td>0.56</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>412</td>
<td>518</td>
<td>3904</td>
</tr>
</tbody>
</table>

*():t-value

5.3 Effect of ITS

We analyzed the sensitivity of the SP1 and SP2 models to parking charge at Katsuragi Station and the probability of choice for Katsuragi Station while keeping the level of service fixed except for the parking charge. Figure 19 and 20 show the change in probability of Katsuragi Station on the station choice model using parking charge of Katsuragi as the variable for the access mode choice model. Figure 19 shows the number of trips from Takezono, about 1 km south of Tsukuba Station. Figure 20 presents the number of trips from Namiki, near the Namiki Ohashi Bus Stop (refer to Figure 3).

For every value of parking charge, the probability of the SP2 model is higher than the SP1...
model. People tend to choose Katsuragi Station with ITS rather than that without ITS for all levels of service. The gap between SP2 and SP1 shown by arrows in Figure 19 and Figure 20 can be said to represent the effects of ITS.

Figure 19 – Effect of ITS in Takezono. Figure 20 – Effect of ITS in Namiki.

Probability is not high in Figure 19 because Takezono is a convenient to access to Tsukuba Station. The gap between SP1 and SP2 increases as the parking charge goes down. On the other hand, the probability in Figure 20 is high because the utility of P&R is higher in areas farther from the station. It shows a slightly similar trend like that in Figure 19. It can be interpreted that in the situation when parking charges without ITS and with ITS are the same, people would prefer to use ITS with lower charge than that with higher charge.

6 CONCLUSION AND FUTURE RESEARCH

In this paper, the WTP for a new parking system with ITS was discussed using a choice behavior model. The research estimated the demand and WTP for parking. Findings indicate that installing ITS technology can increase demand and WTP for parking. The choice behavior model can show the demand change using another access mode, another station or another major mode.

For future research, the following items will be explored using the survey results:

- Total demand for the new railway,
- Behavior change and WTP for other ITS technology (for example, on line reservation system and travel time forecast)
- Cost benefit analysis for the installation of ITS parking
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