# A STUDY ON THE BIS (BUS INFORMATION SYSTEM) CHOICE BEHAVIORS USING STATED PREFERENCE DATA

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**Abstract:** The benefits of the bus information system (BIS) are estimated using stated preference (SP) data from a survey result on bus passenger behaviors with and without the use of the BIS. The effectiveness of the BIS in reducing the travel time is evaluated at different public transit using the SP method. However, BIS will provide the comfortable movement and reliable information to bus passengers and drivers. The approach deals with a logit model in bus passenger behaviors using SP data. SP data collection and processing offers both the BIS sector city (Anyang) and non-BIS sector city (Suwon). In addition, the survey questionnaire consists of information board at bus station (A type), information for inside of bus (B type), and simulated information which included two kinds of information(C type). The most obvious use of BIS is to predict the passenger behaviors. Details of the traffic information selecting procedure and BIS performance evaluations are also discussed in this paper.

Key Words: BIS (Bus Information System), SP (Stated Preference), APTS (Advanced Public Transportation System)

## **1. INTRODUCTION**

Real-time BIS (Bus Information System), which actives public transportation with intelligent transportation system, recently has been promoting around the Metropolitan area. BIS provides related information such as route information, transit information, public transportation information and waiting period information to bus users during before and after transit period and helps passengers with effective transit decision. In addition through this system, a bus driver is able to precisely allocate the dispatching time and a passenger is able to safely and comfortably use public transportation. When Korea Transport Institute researched selecting business priority of ITS service demand research, BIS (Bus Information System) ranks the top as priority business in result. Also when Transportation Information System of Suwon City researched transportation satisfaction in Suwon City, 43 % of high preference ratio, Bus Information System is required, was shown in result among ITS systems. As you can see Public transportation information of bus route are preferred by citizens. However BIS is in need of some more

information from now on and research, how much value obtained by BIS would be, is in insignificant phase at the moment.

We derived hence information of BIS preferred by passengers from real users through interview questionnaires on this research. As we use research of stated preference (SP) to those who use buses, we exhibit a model of Bus Information Selection and value of bus information. The object of this research therefore drives information passengers prefer in information of BIS. A model of information selection is estimated through research of stated preference and an investigative study for explanatory variables and value for bus information are exhibited. Also we exhibit desirable directions and suggestions from now on. We examined characteristic of survey on the second chapter of this research, arranged the survey result on the third chapter and exhibited the contents of model presumption using SP Data and the result of analysis on the fourth chapter.

## 2. CHARACTERISTICS OF SURVEY QUESTIONNAIRES

## 2.1 Survey Outline

The research and collection of research materials have been carried out for 20 days from August 10 to August 30, 2004. Survey method was carried out for users who were waiting for getting on a bus. It was carried out with direct survey in Anyang City in which BIS has been operated and in Suwon City in which BIS hasn't been yet operated. The contents of survey were generally divided into two parts. First as it was general survey, it exhibited analysis regarding satisfaction of provided present bus service, transit purpose and information required hereafter on the fore part of survey. On the latter part of survey, as it was SP survey it established operation hour of bus and a one-way fare. It also established information of information board at bus station (A type), information for inside of bus (B type) and simulated information which included two kinds of information(C type). It was constructed with questions regarding simulated situations in accordance with the change of primary elements.

We distributed 340 copies as shown in the "Table 1" regarding the collection result for survey and 326 copies were valid. The copies which were valid for SP data were 326 copies and the copies which excluded invalid surveys in general data were only 247 copies. The reason it happened was due to passengers who were waiting for a bus received survey for SP data prior to the one for general data. When we considered it in general, valid sampling rate of survey for SP data which was valid for estimation of model was 95.8%. Also valid sampling rate of data for general survey which was to examine understanding of bus information and necessity of BIS was 75.7%.

Data	Number of Sampling	Rate
Stated Preference Data	326	95.8%
(Revealed Preference Data)	(247)	(75.7%)
Unusable Data	14	4.1%
Total	340	99.9%

Note: The reason that is not 100% is decimal point rounding off this.

#### 2.2 Socioeconomic Characteristics of Survey

We divided the areas into Anyang City in which BIS had been operating and Suwon City in which BIS hadn't been yet operated and examined the data. When we looked into the distribution rate by regional group, Anyang City was 117 people (35.9%) and Suwon City was 209 people (64.1%). Suwon City was slightly higher than Anyang City and the male was 3% higher than the female in distribution rate by sex as well.

Twenties occupied 53.3% which was the highest among the groups, 20.5% for thirties and 11.3% for forties in the rate by age. When we looked into characteristic of trip purpose in 326 people of sampling group, school occupied 32.5% which was the highest among the groups, 23% for working place and 19% for house. In case of Anyang City, 52 people chose working place which was the highest among the groups and school was 87 people in Suwon City. In addition in case of under thirties group which occupied 65.3% out of total respondents, the rate, school was chosen for trip purpose, was 32.5% and it was the highest among the groups. In case of forties group, school occupied 15% for trip purpose, house and working place in order.

		School	chool Work	Market	Home	Travel &	Entert-	Others	Total (%)
		School	WOIK	Warket	TIOINC	Business	ainment	Others	10tal (70)
Dagm	ndonta	106	75	7	62	10	45	21	326
Kespt	ondents	(32.5)	(23.0)	(2.1)	(19.0)	(3.0)	(13.8)	(6.4)	(100)
Area	Anyang	19	52	4	24	3	9	6	117 (35.9)
	Suwon	87	23	3	38	7	36	15	209 (64.1)
Sex	Male	67	38	NA	27	7	21	9	169 (51.8)
	Female	39	37	7	35	3	24	12	157 (48.1)
Age	0-29	104	28	3	29	4	28	11	207 (63.5)
	30-39	2	35	1	12	1	12	4	67 (20.5)
	40-49	NA	8	1	15	4	4	5	37 (11.3)
	Above 50	NA	4	2	6	1	1	1	15 (4.6)

**Table 2. Characteristics of Trip Purposes** 

Note: NA (No Account)

## **3. SURVEY RESULT**

## 3.1 Responses for Bus Services

In the survey result of satisfaction for bus service, "average" was the highest with 52.2% and "inconvenience" occupied 30.3% of respondent rate. Especially 71% of respondents strongly felt the provision of BIS was desperately required. Only 2% of respondents who replied information were not needed to be furnished.



Figure 1. Satisfaction of Bus Service at Ordinary Times



Figure 2. Necessity of Bus Service Improvement

In regards of inconvenience of bus service at ordinary times, 29.5% of respondents pointed out "Irregular operating schedule for time table" as the first ranking. Next 28.7% of respondents pointed out "Uncertainty of arrival time". The reasons respondent felt inconvenient were "Irregular operating schedule for time table", "Uncertainty of arrival time" and "Unexpected traffic jam" in the second ranking.

	First Ranking	Second Ranking
	Respondents (%)	Respondents (%)
Uncertainty of Arrival Time	71 (28.7)	46 (18.6)
Irregular Operating Schedule for Time Table	73 (29.5)	62 (25.1)
Poor Services	12 (4.8)	19 (7.7)
Inaccurate Information	5 (2.0)	8 (3.2)
Costly Fare	35 (14.1)	30 (12.1)
Complicated Bus Route Map and Change For	8 (3.2)	14 (5.7)
Too Much long Walking Distance	8 (3.2)	16 (6.5)
Unexpected Traffic Jam	28 (11.3)	40 (16.2)
Environmental Pollution and Noise	7 (2.8)	10 (4.0)
Others	NA (0)	2 (0.8)
Total	247 (99.6)	247 (99.9)

Table 3. The Reasons of Inconvenience of Bus Service at Ordinary Times

Note: NA (No Account), 100% do not work because of the decimal point rounding off. The reason why divided into 1 rank and 2 rank is to present more diversity point of view and consideration.

# 3.2 Responses for Bus Information

When we examined trip purpose to feel necessity of Bus Information, 69.9% of entire respondents replied "commute and attending school" as the first ranking in result. Next 9.7% for "business purpose" and "personal purpose". On the second ranking of transit needed Bus Information, "personal purpose", "business purpose" and "traveling and leisure purpose" were replied.

	First Ranking	Second Ranking
	Respondent (%)	Respondent (%)
Commute and Attending School	172 (69.9)	27 (10.9)
Business Purpose	24 (9.7)	59 (23.9)
Traveling and Leisure Purpose	19 (7.7)	33 (13.4)
Go to Market and Shopping	6 (2.4)	15 (6.1)
Personal Purpose	24 (9.7)	109 (44.1)
Others	1 (0.4)	4 (1.6)
Total	246 (99.8)	247 (100)

Table 4. The Trip Purpose to Feel Necessity of Bus Information

Note: 100% do not work because of the decimal point rounding off.

On preference survey for Bus Information by class, "very important" and "important" were only regarded as the number of preferred responses. Percentage means value divided by parameter (247 people) for the number of responses and the result is as following "Table 5". When we can see the result analyzed on "Table 5", Bus Information passengers needed is " The necessary time for bus arrival and information of arrival time (216 people, 87.4%). "The necessary time for bus arrival and information of arrival time" is major function of BIS provides traffic information data for passengers at real-time. This is required because it is able to reduce travel time and increase pleasantness for users.

Information	Responses (%)
The Necessary Time for Bus Arrival and Information of Arrival Time	216 (87.4%)
Accuracy of Information	190 (76.9%)
Information of Bus Route and Transit	189 (76.5%)
Information of The Fastest Way to Get to Destination	167 (67.6%)
Information of Congestion Area by Blocks	150 (60.7%)
Delivery Method of Information	140 (56.7%)
Affordable Service Fee	128 (51.8%)
Incident Duration Information (Road Construct, Traffic Accident)	121 (49.0%)
Government and Public Offices Location Information	95 (38.5%)
A Variety of Information	94 (38.1%)
Traffic Facilities and Reservation Services (Subway, Train, Airport)	71 (35.2%)
Provision of Wireless Internet Service	71 (28.7%)
Convenient Information for Users Like Weather and Cultural Events, Etc	64 (25.9%)
Reservation Services (Theater, Workout Facilities, Amusement Park, Etc)	53 (21.5%)
Information of Living (Headline News, Stock and Regional Events, Etc)	47 (19.0%)

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Next "Accuracy of information (190 people, 76.9%)" and "Information of bus route and transit (airport, bus terminal and subway stations) (189 people, 76.5%)" was information more than 70% of respondents needed. Also users desperately needed "Information of bus route and transit (airport, bus terminal and subway stations)", "Information of the fastest way to get to destination" and "Information of congestion area by blocks" as related information. It also exhibited that respondents didn't desperately need additional service items such as "Provision of wireless internet service" "Convenient information for users like weather and cultural events, etc" and "Information of living (headline news, stock and regional events, etc)" so far.

Meanwhile it exhibited respondents needed information to be provided at real-time such as "Information of the fastest way to get to destination" and "Information of congestion area by blocks". We therefore concluded continuance and sequence of information provision should be considered when we provided Bus Information.

	First Ranking	Second Ranking
	Responses (%)	Responses (%)
Delivery Through Internet	32(12.9)	25(10.2)
The Board at Bus Station	157(63.6)	41(16.6)
Provision of PDA Information at a Bus	22(8.9)	36(14.6)
Voice Information Inside of a Bus	26(10.5)	70(28.3)
Information of Monitor Picturing Inside of a Bus	10(4.0)	74(30.1)
Total	247(99.9)	246(99.8)

## Table 6. Preferences as Delivery Types

Note: 100% do not work because of the decimal point rounding off.

When we looked into preference of delivery method for Bus Information, 63.6% of entire respondents replied "The board at bus stations" as the first ranking and preferred "Delivery through internet" was the next. On the second ranking of preference for delivery methods, "Information of monitor picturing inside of a bus", "Voice information inside of a bus" and "Provision of PDA information at a bus station" were replied.

## 3.3 Responses of BIS System Users in Anyang City

We researched survey to system users in Anyang City in which BIS has been already operating. When we asked frequency to use information at information stand of a bus station, 44 respondents replied "Use sometimes" and it occupied 48%, which was the largest number. Also 23 people replied, "Use frequently" and it occupied 24%. When we researched satisfaction of information provided at information stand of a bus station, 43 respondents replied "average" and it occupied 46%, which was the largest number. 41 respondents replied "satisfaction" and it occupied 42.7%.



Figure 3. The Rate of Using about BIS



**Figure 4. Preference Rate about BIS** 

For trip purpose when Bus Information is very usefully used, 68 respondents replied, "commute and attending school" and it occupied 70.8% which was the largest number. 13.5 % of people replied "shopping and dilettante life" and 12.5% for "working and household duties".

Table 7. The Most Useful Time of BIS

	Work and school	Business	Shopping	Travel	Others	Total
Responses	68	12	13	1	2	96
Per cent	70.8	12.5	13.5	1.0	2.1	99.9

Note: 100% do not work because of the decimal point rounding off.

The reason that classified five trip purposes is to examine more efficiently.

In regards of time they would like to be provided Bus Information, 53 people replied "before leaving a house" which they preferred the most with 55.2% and 39.6% for "after arriving at a bus station".

Table 8.	The	Best	Point	of Time
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	Before leaving home	At bus stop	En trip	Before 1 hours	Others	Total
Responses	53	38	NA	3	2	96
Per cent	55.2	39.6	0	3.1	2.1	100

When we researched a reason Bus Information is useful, 57.3% of entire respondents pointed out "If information of arrival time is provided, we don't have to aimlessly wait for a bus" as the first ranking. Next 27% of respondents pointed out "Enable to forecast time to destination". On the second ranking of useful reasons, "Enable to forecast time to destination", "Information of bus route situation" and "If information of arrival time is provided, we don't have to aimlessly wait for a bus" were replied.

	First Ranking	Second Ranking
	Respondents (%)	Respondents (%)
Enable to Forecast Time to Destination	26 (27.1)	34 (35.4)
I Don't Want to Aimlessly Waite for a Bus	55 (57.3)	18 (18.7)
To Know Allocation of Bus	1 (1.0)	5 (5.2)
To Know a Change of Bus	7 (7.3)	11 (11.5)
To Know Incidental Duration	NA (0)	6 (6.3)
Information of Bus Route Situation	7 (7.3)	22 (22.9)
Total	96 (100)	96 (100)

## Table 9. Reason of Bus Information is Useful



## Figure 5. Reason of Bus Information is Useful

When we researched a reason Bus Information is not useful, 52.1% of entire respondents pointed out "Insufficient of information contents and low accuracy" as the first ranking. Next they pointed out "Sufficient only with own experience and observation". On the second ranking of useless reasons, "Information is not helpful for transit", "Insufficient of information contents and low accuracy" and "Sufficient only with own experience and observation" were replied.

	First Ranking	Second Ranking
	Respondents (%)	Respondents (%)
Insufficient of Information Contents and Low Accuracy	50 (52.1)	22 (22.9)
Sufficient Only with Own Experience and Observation	28 (29.2)	17 (17.7)
Information is Not Helpful for Trip	17 (17.7)	46 (47.9)
Others	1 (1.0)	11 (11.5)
Total	96 (100)	96 (100)

Table 10. Reason of Bus Information is Not Useful

#### 4. ESTIMATION OF MODEL USING SP DATA

#### 4.1 Concept of Model

The theory of maximizing utility "An individual chooses the most preferred selection index among available selection index" was based on this research. Discrete choice model made related selection problem of 0 and 1 whether an individual used a bus or not and was applied on this research. On the theory of maximizing utility, an individual firstly chose available selection index and next chose the most preferred selection index in the rest. Utility of alternative selection (i) was constructed confirmed term about a factor, which enables to be observed and probability term which is stochastically changed by a factor unable to be observed (unobserved utility). When we assumed linearity of this, it is as following "equation 1".

$$Uj = Vj + ej$$
(1)

We consider variables which influences on bus selection of BIS as assumption including travel hour of a bus (R time), a one-way fare of a bus (Cost), information of a bus station (A type), information of inside bus (B type), and simulated information, which included two kinds of information(C type). Transit utility that a certain person uses BIS (Bus Information System) can be shown as following a straight line formula.

$$Uj=\beta 1+\beta 2\cdot Rtime+\beta 3\cdot Cost+\beta 4\cdot Atype+\beta 5\cdot Btype+\beta 6\cdot Ctype$$
(2)

In case of checklist question, which chooses selection index 1 among an available selection index group, logit model formula can be shown as following a formula and this kind of logit model is used on this research.

$$Pin = \exp(Vi) / \sum \exp(Vj)$$
(3)

Statistical and significant test of estimated parameter value for logit model considers coefficient of t-test. When degree of freedom is 8 and absolute value of statistic value is bigger than 1.960(2.576) in 95%(99%) of reliability, we consider as a factor, which is statistically significant and influences on selection possibility. As it is an indicator to decide goodness of fit for a model,  $\rho 2$ (rho-squared: likelihood ratio index) which shows explanation of a model is used and it is calculated as follow.

$$\rho 2=1-L(\beta)/L(0) \tag{4}$$

L( $\beta$ )is maximum value of log likelihood function and it is value of log likelihood function when all coefficient values are 0. L(0) can be log likelihood of a model; possibility two alternatives are chosen is 1/2.  $\rho$ 2 is a conception similar to  $R^2$  (Coefficient of Determination) at regression analysis and has value between 0 and 1. When it is close to 1, it shows good adaptation.  $\rho$ 2 has relatively smaller value than  $R^2$  general one. When  $\rho$ 2 has value between 0.2 and 0.4, it is known an estimated model has a very good adaptation.

## 4.2 Estimation of Model

"Table 11" shows the estimated result of a model obtained by input of observed data at TSP program. We assume a model compares transit time, transit fare and information methods and chooses one either a general bus or a bus with BIS.

In result of estimation, transit time and a fare show a negative sign. As transit time is long and a fare is high, selection possibility of BIS bus is decreased. This therefore cannot be considered as an appropriate sign. Also coefficient of variables which provides two kinds of information among Bus Information is exhibited higher than the rest two and it is shown that diversity of information is preferred. When we look into adaptation of a model, t value of a parameter is significant statistically and likelihood ratio ( $\rho$ 2) also shows 0.148 which is close to 0.2 so we consider this is as a satisfied model.

Variable	Estimate	T-statistics	
In-Vehicle Time(R time)	-0.0879	-9.600**	
Bus fare(Cost)	-0.004 -13.512		
Information at Bus Stop(A type)	11.397	65.559**	
Information on board(B type)	11.473	72.809**	
Both of two(C type)	12.533	88.573**	
Sample(n)	1484		
L(0)	-1028.6		
L(β)	-875.56		
ρ2	0.1488		

## Table 11. Result of Model Estimation

Note; \*\* indicates significant difference at the 1% level

In result of regional model estimation, explanations of estimated coefficients for two models are generally estimated at high value excluding variables for information of a bus station in Anyang area. Anyang and Suwon are appeared that they sensitively react for information including two kinds of information. Likelihood ratios ( $\rho$ 2) are respectively 0.16 and 0.15 and are considered relatively satisfying. Also it is analyzed time value of Anyang area is 1.549 and it is 500 won higher than Suwon City. It is the result users in Anyang area estimated information value higher than users in Suwon area since users in Anyang area who already have been experienced BIS and satisfied with the system.

While a policy data introduced a system to the survey result recognized a thing unconsciously, policy response convenience generated the respondents. Persuasion is determined that the Anyang City respondents which experienced service is not affected by all kinds of convenience

with a model, and therefore assumed to be the result that made up a question correctly in this study.

Variable	Anyang	<b>T</b> -statistics	Suwon	<b>T-statistics</b>
R time	-0.1059	-6.8436**	-0.0784 -6.8802*	
Cost	-0.0041	-7.5365**	-0.0046	-11.1557**
A type	0.4188	1.3948	12.2193	57.0478**
B type	0.5990	2.2581*	12.2442	62.2833**
C type	1.8261	7.7206**	13.2137	74.4393**
Sample (n)	519		965	
L(0)	-359.74		-668.89	
L(β)	-302.45		-570.43	
ρ2	0.15925		0.1472	
Value of Time (won per hour)	1549		1022	

 Table 12.
 Result of Regional Model Estimation

Note; \*\* indicates significant difference at the 1% level

\* indicates significant difference at the 5% level

In result of estimation for a model by sex, t-value of parameter is generally significant as Table 13. Adaptation (likelihood ratio,  $\rho 2$ ) is about 0.104 ~ 0.215 and it shows relatively satisfied value. In case of a men's small group, it is shown that estimation coefficient of information including two is insignificant. Also preference for information including men and women(C type) with market division is exhibited at high value.

Variable	Man	<b>T-statistics</b>	Woman	<b>T-statistics</b>	
R time	-0.0591	-5.173**	-0.1330	-8.179**	
Cost	-0.0035	-8.770**	-0.0060	.0060 -10.034**	
A type	-0.9033 -3.778**		6.3267 24.322**		
B type	-0.9861	-4.845**	6.7396	26.202**	
C type	-0.2689	- 1.463	8.2519	35.171**	
Sample (n)	768		716		
L (0)	-532.34		-496.29		
L (β)	-476.94		-389.52		
ρ2	0.10406		0.21514		

 Table 13.
 Result of Regional Estimation by Sex

Note; \*\* indicates significant difference at the 1% level

\* indicates significant difference at the 5% level

In case of market divisible by age, it is as following "Table 14". Also in case of a small group with less than 40 years, it is shown that estimation coefficient for inside of a bus information (A type) is not significant. Estimation coefficients of the rest are shown that they are significant at 1% of significant level. Bus Travel hour (R time) and a one-way fare of a bus (Cost) show a negative value in all. For code of information, all variables excluding information of a bus station (A type) and inside of a bus show positive values. In case of sensitivity for information, coefficient of information variable including two in all age group (C type) shows at high value.

Variable	- 29	T-statistics	30-39	T-statistics	40+	T-statistics
R time	-0.0952	-8.153**	-0.0842	-4.186**	-0.0823	-3.356**
Cost	-0.0048	-11.309**	-0.0033	-4.769**	-0.0047	-5.632**
A type	-0.9582	-4.217**	3.1365	8.032**	1.0967	2.783**
B type	-0.6797	-3.319**	3.3722	10.068**	0.1511	0.369
C type	0.5676	3.130**	3.7708	12.230**	1.7050	4.807**
Sample (n)	937		302		245	
L (0)	-649	9.48	-209.33		-169.82	
L (β)	-540.97		-180.98		-140.33	
ρ2	0.16707		0.1354		0.1736	

Table 14.	Result of	Regional	Model	Estimation	by .	Age
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Note; \*\* indicates significant difference at the 1% level

\* indicates significant difference at the 5% level

# 5. CONCLUDING REMARKS

In order to find out choice behavior of BIS, survey has been executed to bus users on this research. In addition we divided bus users into Anyang City in which has been already experiencing BIS and Suwon City in which hasn't yet been executed and we estimated and compared with a regional model. In result of survey, "irregular operating hour" and "uncertainty of arrival time" are the major factors bus users felt mainly uncomfortable for bus service. Also they preferred "Information of estimated time to arrive and arrival time" and "Information of a bus route and transit" as Bus Information. 63.6% of respondents preferred "Information provision through a board at a bus station" as information method.

In case of logit model by preference investigation, coefficient values of bus operation hour and a one-way fare of a bus were negative. It is shown as the expenses were increased, information selection was decreased. Also coefficient value for information showed positive value. Information including two kinds of information more sensitively reacts than the rest in all kinds of Bus Information method. It was analyzed that Anyang area was 1,549 (won/time) and Suwon area was 1,022 (won/time) for cost value of information.

We determined changes of transit hour and costs and information pattern as factors in order to analyze information preference pattern of BIS. We therefore surveyed preferences and analyzed preference behavior of BIS. However in order to survey information preferred by bus users, we need to more diversely consider than convenience of transit facilities, pleasantness to use a bus and traffic conditions around areas. A mode of this research has a limitation as we are not able to analyze these kinds of points and therefore we need to study further hereafter.

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