Modeling the Relationship Between Travelers' Level of Satisfaction and Their Mode Choice Behavior Using Ordinal Models

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Travelers' level of satisfaction is an important performance measure for transport service providers and a determinant of mode choice. However, its computation is not easy because of the complicated and unique characteristics of travelers. The traditional method of comparing yearly satisfaction percentages has been implemented in several places; however, it does not include the interrelationships between variables that determine satisfaction. This study estimates travelers' level of satisfaction using an ordered logit model and then uses the results in a binary mode choice model. The results show that the level of satisfaction has a significant influence on the modal choice characteristics of travelers.

INTRODUCTION

A high level of satisfaction with public transportation services reflects public confidence and the willingness of people to use the service. It is also an important performance measure for transport service providers and a determinant of mode choice. However, determining the level of satisfaction is not easy because of the complicated and unique characteristics of travelers. People tend to be satisfied when their perceptions of the service they receive match their expectations. When the service falls short of their expectations, they tend to be dissatisfied. As discussed in Donovan et al. (2001), different factors such as efficiency, reliability of the service and responsiveness of the service provider contribute to people's perceptions and levels of satisfaction with service. The absence of some of these factors can have a strong impact on dissatisfaction levels, while the presence of others may sometimes be taken for granted; hence better service may always not lead to higher satisfaction levels. Moreover, people may be willing to tolerate small variations in some of these factors without any impact upon their level of satisfaction with service.

The level of satisfaction is not only dependent on service quality but on travelers' socio-economic backgrounds. Therefore, this research estimates the relationship between level of satisfaction and socio-economic variables, and analyzes the effect of satisfaction with service on mode choice. In doing so, the study uses the public transport in Addis Ababa (the capital of Ethiopia) as a case study.

PREVIOUS RESEARCH

The traditional method of measuring satisfaction is to compare yearly satisfaction percentages. For example, the Scottish Executive Social Research on bus passengers' satisfaction considers 29 bus service variables to analyze citizens' satisfaction year-by-year (Buchanan 2004). Though the same method is used by several consultants and transit companies (TCRP 1999; Ostlere and Lund 2008), there are attempts to use probability models to analyze travelers' satisfaction with service. Cees et al. (1999), for example, estimated ordinal models of satisfaction using a binomial logit model. Eboli and Mazulla (2007) used a structural equation model to show the relationship between passenger satisfaction with bus services and the attributes of the services supplied without considering the socio-economic background of the respondents.

Binary and multinomial logit models have also been used to analyze mode and route choice behaviors of travelers (Arasan et al. 1996; Ghareib 1996; Yamamoto et al. 2000; Mintesnot and Takano 2005). In these studies, trip characteristics (e.g., length of trip, time of the day, and trip purpose), the socio-economic characteristics of trip makers, and the characteristics of the transport system have generally been found to be important determinants of mode choice. David and Edward (2004) add land use characteristics and urban design as determinants of mode choice. Despite these efforts, the influence of perception and satisfaction on mode choice has received little attention, especially the application of ordered logit models.

This paper extends the combined use of binary and ordered models in analyzing mode choice with the purpose of identifying the influence of perception and satisfaction on mode choice. It answers the question, "Which factors affect the level of satisfaction with service and mode choice behavior?"

METHODOLOGY

Choice of Study Area

Addis Ababa is the capital of the Federal Democratic Republic of Ethiopia and is located in the center of the country. Established in 1886, the city has experienced several planning changes, all of which have influenced its physical and social growth (Figure 1). Addis Ababa covers an area of 530.14 square kilometers. Its population is 3.11 million (2005 estimate), which is about 3.9 % of the population of Ethiopia and 26 % of the urban population of the country (Addis Ababa City Transport Authority 2004).

Figure 1: Addis Ababa City Map

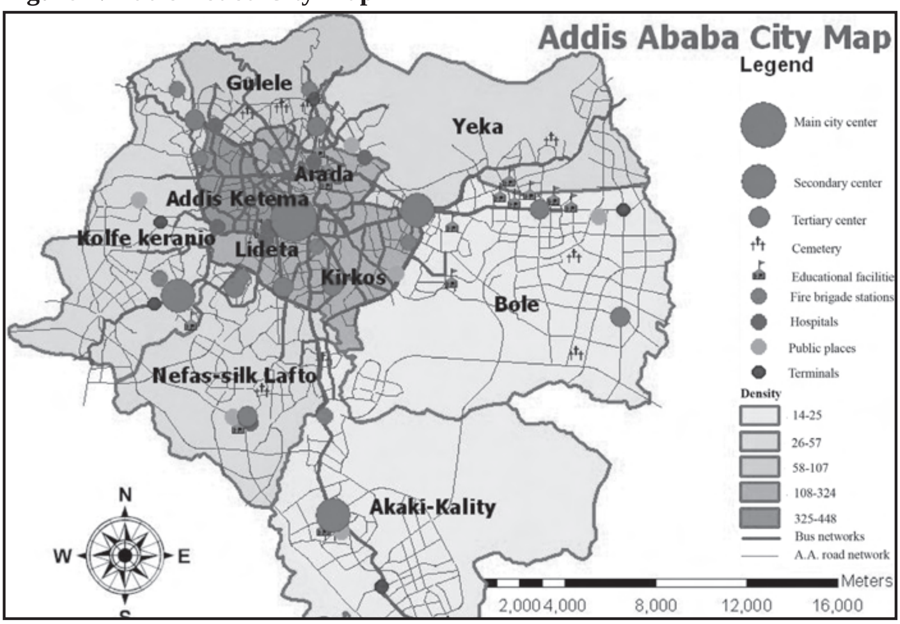


Figure 2 shows that public transport in the city consists of conventional bus services provided by the publicly owned Anbessa City Bus Enterprise, taxis (small and mini-van taxis) operated by the private sector, and buses used exclusively by the employees of large government and private companies. Bicycle transportation is insignificant because of topography and there is no rail service. Buses serve 40% of the public transport needs of the city, while taxis account for 60% (Ethiopian Road Authority 2005). The city is currently experiencing horizontal growth and the bus service has not been able to respond to it. Data on transit availability (capacity, coverage, and frequency

Figure 2: Overview of Public Transport in Addis Ababa City

Photo credit: Befekir Kebede

indicators) show that the existing bus networks serve mainly the center city (Mintesnot and Takano 2006). Taxi services are constrained by bad driver behavior, excessive fares and high accident rates, and the road capacity is limited in extent and by on-street parking and poor pavement condition. Despite a large volume of pedestrians, 63% of the roads have no sidewalks and this contributes to increased pedestrian involvement in traffic accidents. In 2004, 10,189 accidents involved pedestrians (Ethiopian Road Authority 2005).

Data

The data to estimate these models are from a survey conducted in September 2004 to analyze bus travelers' satisfaction with public transportation services. The questionnaire included socio-economic variables, demographic characteristics, travel patterns, mode attributes, satisfaction indicators, and bus service condition data. A door-to-door survey was done and involved 750 households from the inner city, intermediate zones, and outlying areas of Addis Ababa. From the survey in Figure 3, 64% of the respondents use the bus as their typical mode of transportation, 18% use taxi, and 12% walk. The remaining respondents use other modes of transportation such as private cars. These results contrast the findings of the Ethiopian Road Authority (2005) which show that walking has the largest share of overall trips if all short distance trips are included. Including walking from home to the bus or taxi stations, the majority of the respondents make six trips per day on the average (see Figure 3).

Concerning the socio-economic and demographic characteristics of the respondents, 58% were male and their monthly incomes ranged from below 100 to 2000 Ethiopian Birr ($1.00 ≈ 9 ETB). However, most respondents received between 100 and 300 ETB monthly. This leads us to conclude that the majority of the respondents are the low-income earners. About 35% were public company employees, 19% private company employees, 24% operated their own small businesses, 8% were students, and the remaining 14% were unemployed. Also, more than 90% of the respondents had no car or driving license. Family size ranged from one member to 11 members and the average

Figure 3: Modal Split

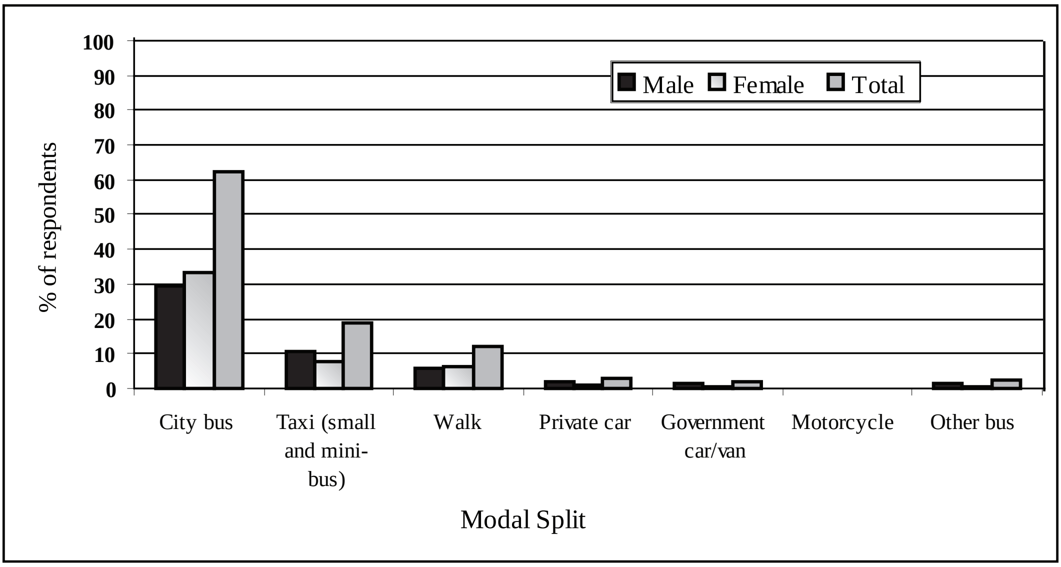
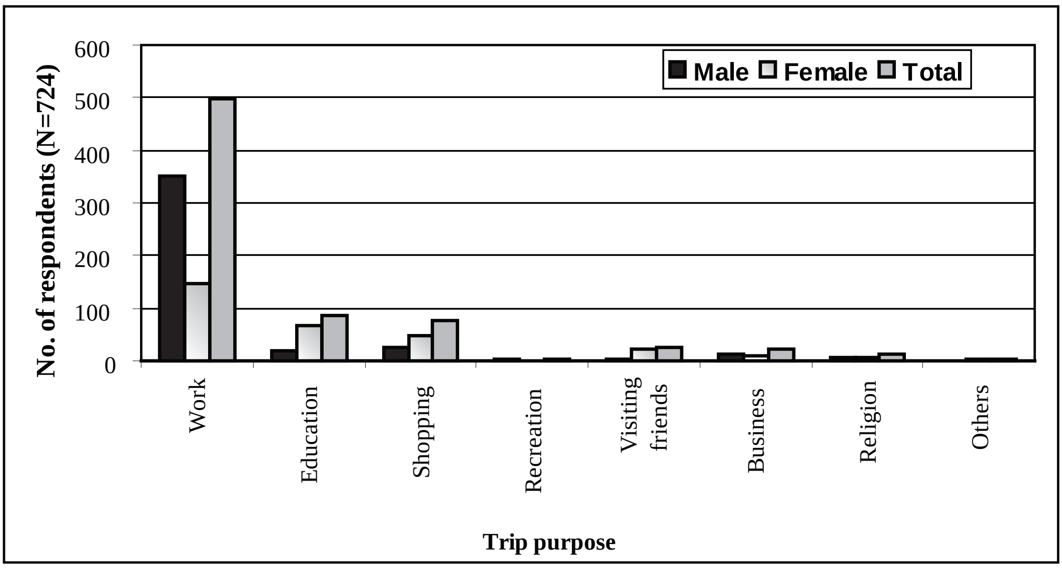


Figure 4: Trip Purpose



household size is 5.08. Very similar to what the Ethiopian Road Authority (2005) found, Figure 4 shows that going to work was the main purpose of these trips followed by involvement in educational activities.

Regarding the general satisfaction with bus service, 57% of the respondents said they were satisfied. Bus service attributes were broken down into bus stop facilities (bus shades/shelters, information, cleanliness), drivers' and fare collectors' behavior (drivers and fare collectors handling of passengers), schedule adherence (does the bus arrive as scheduled?), bus transfer (convenience of transfer), bus frequency (how often the bus comes), boarding convenience (ticketing, passengers' behavior, long queues), and bus design (steps, bus doors, seat comfort). The respondents showed

Table 1: Descriptive Statistics

Variables (N=648)	Mean	Std.Dev.	Measurement
General satisfaction (0, 1, 2)	1.55	0.53	Ordered
Satisfaction variables on bus service attributes (0, if dissatisfied, 1, if less satisfied, and 2, if satisfied)			
Drivers' behavior (0, 1, 2)	1.96	0.63	Ordered
Bus stop facilities (0, 1, 2)	1.41	0.73	Ordered
Schedule (0, 1, 2)	1.75	0.68	Ordered
Bus linkage (0, 1, 2)	2.42	0.70	Ordered
Bus frequency (0, 1, 2)	1.61	0.72	Ordered
Boarding convenience (0, 1, 2)	0.93	0.81	Ordered
Bus design (0, 1, 2)	2.41	0.71	Ordered
Mode: 1 for bus users and 0 for taxi users	0.779	0.415	Binary (0,1)
Socio-economic and mode-related variables			
Zone: *0 if inner, 1 if intermediate,2 if outlying*	0.962	0.805	Ordered
Age	40.148	14.268	Continuous
Gender: *1 if male, 0 if female*	0.557	0.497	Binary (0,1)
Occupation: *1 if employee (workers) and student 0 otherwise*	0.619	0.486	Binary (0,1)
Monthly income	498.957	378.529	Ethiopian Birr*
Family size	5.093	1.885	Continuous
Trip Purpose: *1 if work and edu.,0 otherwise*	0.786	0.410	Binary (0,1)
No. of bus connections (transfers)	5.794	1.416	Continuous
In-vehicle time (in-bus minus in-taxi time)	23.060	23.241	Minutes
Waiting time (bus minus taxi waiting time)	12.808	14.949	Minutes
Fare (taxi minus bus fares)	75.000	24.449	Ethiopian cents

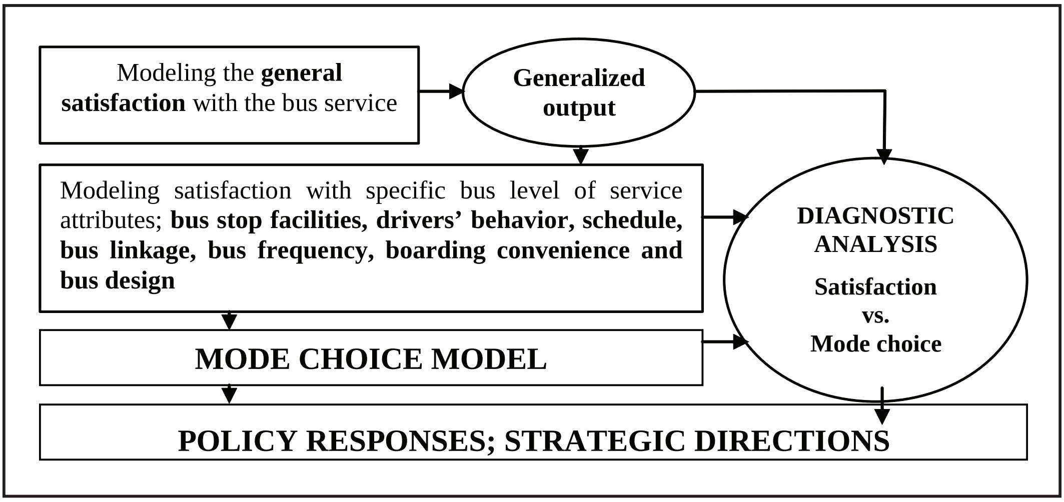
* 1 Ethiopian Birr ≈ 9 USD
1 Ethiopian birr = 100 cents

dissatisfaction with bus schedule, bus frequency, boarding convenience, bus stop facilities, and drivers' behavior. Only on two attributes did they show satisfaction, i.e., bus transfers and bus design (Figure 7). The descriptive statistics (mean, standard deviation and unit of measurement) of satisfaction variables, socio-economic, and mode-related parameters are presented in Table 1.

Analytical Methods

Figure 5 summarizes the approach used in this paper. Two models were developed; the first is an ordered logit model which relates the effect of level of satisfaction to public transport mode choice. In this model, a general measure of satisfaction is used as the dependent variable and the independent variables are traveler and trip characteristics. Similar models were developed to relate traveler and trip characteristics to satisfaction with specific bus service attributes. The second is a binary choice logit model whose dependent variable is public transportation coded as a one if the mode is bus and a zero if it is a taxi. From these models, the study determines the impact of satisfaction on mode choice.

Figure 5: Analytical Framework



Ordered Logit Model: Travelers' Satisfaction Model: Ordered logit and probit models, instead of regression, have been used widely to analyze ranked responses because they have the capability of handling such variables (Green 2000). For this reason, they are used to model passenger satisfaction with bus level of services. Suppose that the values of *Y* represent an ordering of items. For example, let Y_i be the level of satisfaction of a bus passenger i, coded as:

(1) $$Y_i = \begin{cases} 0\text{: not satisfied} \\ 1\text{: Less satisfied} \\ 2\text{: Satisfied} \end{cases}$$

Y is not a quantity but ranking and a larger value means more or better satisfaction with the service. In this case, there exists a known natural number, m, such that

(2) $$P\,[Y_i \in \{0, 1, 2 \ldots m\}] = 1$$

This type of data is usually modeled via a latent (unobserved) variable model:

(3) $$Y^*_i = \alpha + \beta_i{}'X_i + \varepsilon$$

Y^*_i = latent (unobserved) measure of satisfaction faced by the respondent,
X_i = a vector of explanatory variables describing the demographic, socio-economic, and mode-related variables such as waiting time, travel time, etc.
α, β' = coefficients to be estimated, and
ε = a random error term (assumed to follow a standard normal distribution for probit model or logistic distribution for logit model).

The observed or coded discrete satisfaction variable, Yi, is determined from the model as follows;

(4) $$Y_i = \begin{cases} 0 \rightarrow \textit{Dissatisfied if } Y_i^* \leq 0 \\ 1 \rightarrow \textit{Less satisfied if } 0 < Y_i^* \leq \mu_1 \\ 2 \rightarrow \textit{Satisfied if } Y_i^* > \mu_1 \end{cases}$$

Where μ_i is a set of thresholds of the satisfaction gap to be estimated with the parameter vector β and α. The probability, associated with the coded responses of an ordered probability model, is as follows:

(5) $$\Pr(Y_i = j) = \Pr\left(\mu_{j-1} < Y_i^* \leq \mu_j\right) = \Pr\left(\mu_{j-1} < \left[\alpha + \beta_i' X_i + \varepsilon\right] \leq \mu_j\right)$$

Where, j represents the ranked value of satisfaction. The random error 'ε' is such that:

(6) $$Pr\ (Y_i=j)= Pr\ (\mu_{j-1}<Y^*_i \leq \mu_j)=F(\mu_j- \alpha - \beta_i 'X_i) - F(\mu_{j-1} - \alpha - \beta_i 'X_i)$$

In a simplified form,

(7) $$Pr\ (Y_i=0) = F\ (\alpha - \beta_i X_i)$$

(8) $$Pr\ (Y_i=1) = F\ (\mu_1-\alpha - \beta_i X_i)-F\ (\alpha - \beta_i X_i)$$

(9) $$Pr\ (Y_i=2) = 1- F\ (\mu_1-\alpha - \beta_i X_i)$$

In ordered logit, F(x) is specified as the logistic distribution function.

(10) $$F(x) = exp(x)/ [1 + exp(x)]$$

For the ordered logit model (satisfaction model), the dependent variable is the ranking of the responses regarding satisfaction with bus service attributes (0 = dissatisfied, 1 = less satisfied, 2 = satisfied). The independent variables are the socio-economic, demographic, and mode-related parameters such as age, sex, occupation, monthly income, family size, mode, fare, travel time, and waiting time. While the ordinal model estimates relationships between the level of satisfaction and travelers socio-economic and travel characteristics, estimating a mode choice model with the same independent variables makes it possible to build a connection between satisfaction and mode choice. The mode choice results can be used to compare the attractiveness of travel by different modes to determine their relative usage whereas travelers' satisfaction can be used to predict changes in mode choice.

Binary Logit Model: Public Transport (PT) Mode Choice Model: Choice models are widely used in economics, marketing, transportation, and other fields to represent a choice among a set of mutually exclusive alternatives. Several models have been developed to analyze choice behavior especially in demand analysis. When the choice makers are faced with two dominant alternatives, it is a binary choice case. The derivation of any binary choice model is conceptually straightforward in that once the probability of alternative *i*, ($P(i)$) is obtained, the probability of *j* is [$1 - P(i)$]. The general form of the binomial logit model is the same as equation (10) with the dependent variable replaced by ($P(i)$). The major modes of public transportation in this study are bus and taxi; walking is excluded because it is not used for long trips. The data are organized in such a way that the probability of choosing a bus over a taxi is coded as a one or a zero if the choice is a taxi (i.e., mini-vans operated as taxis). The model is based on utility theory, which assumes the decision maker's preference for an alternative is captured by a value called utility (U). The decision maker selects the alternative in the choice set with the highest utility: U (alternative i) = $\beta_i x_i$, where β_i is the coefficient associated with the variable, x_i, and it is estimated by the model (Green 1998). Selecting the mode with the largest value of utility U is equivalent to selecting the mode with the smallest value of expected disutility D.

RESULTS

Ordered Logit Model Results

The results in Table 2 show the general level of satisfaction as well as the degree of satisfaction with different bus service attributes. The R^2 values for the general equation and the equations for the service attributes are greater than 0.86 showing that the models fit the data set well. All the Chi square values are greater than the critical value (21.03) for the given degrees of freedom (12) and 5% significant level. Several socio-economic and mode-related variables have statistically significant coefficients at the 5% level while others do not. Those variables whose coefficients are not statistically significant are not included in the following discussion.

General Satisfaction

From columns two and three of Table 2 gender, bus transfers, bus travel time, and trip purpose have statistically insignificant coefficients even though their signs indicate their tendency to increase or decrease general satisfaction with service. The table also shows that those who live in outlying areas of the city are dissatisfied with the general bus condition, and as age increases the probability of being satisfied with the bus service decreases. This implies that older people do not consider the existing bus service favorably. Another result is that as monthly income increases, being satisfied with the bus service increases. Despite this finding, it is noteworthy that typically high-income earners are not bus users so their judgments could be from observations rather than from their experiences. In comparison, workers and students show satisfaction with the bus service and people with large families are dissatisfied with it. Higher bus fares and longer waiting times also contribute to less satisfaction with the service, according to the results.

Satisfaction with Bus Service Attributes

Drivers' and fare collectors' behavior: In column four of Table 2, those living in outlying areas show higher levels of satisfaction with driver and fare collector behavior (coefficient of 0.3) compared to inner city residents. Also, the coefficient of those who use the buses to get to work is 0.13. Being statistically significant, this coefficient shows that such people have higher levels of satisfaction with driver behavior. But with coefficients of -0.02 and -0.01 respectively that are statistically significant, travelers with longer waiting times and high monthly incomes are less satisfied with driver behavior. Similarly, employees and students have a relatively high coefficient of -0.21 that is statistically significant, showing that they too express higher levels of dissatisfaction with driver and fare collector behavior.

Bus Stop Facilities: A number of independent variables have significant positive or negative effects on satisfaction with bus stop facilities. Outlying area residents, workers and students, travelers who pay higher fares for their trips, and high monthly income earners show dissatisfaction with bus stop facilities because their coefficients are negative and statistically significant. However, bus users and travelers whose trips involve many transfers show satisfaction with bus stop facilities because their respective coefficients are 0.4 and 0.13, and they are statistically significant.

Schedule: Because zone is coded as a zero for inner city residents and a one for residents of outlying areas, and the coefficient of this variable is positive and statistically significant (0.17), inner city residents are not satisfied with bus schedules but residents of outlying areas are satisfied with these schedules. This may be because in the inner city, traffic congestion makes buses fall behind schedules. Workers and students, bus users, and travelers whose trips involve many transfers appear satisfied with bus schedules. Another finding is that longer travel time is positively related to satisfaction with schedules. This shows that those who use the buses for long trips find that the buses

Table 2: Ordered Logit Model Results: Satisfaction with General and Specific Bus Service Attributes

	General satisfaction		Satisfaction with specific bus service attributes													
			Drivers behavior		Bus stop facilities		Schedule		Bus linkage		Bus frequency		Boarding convenience		Bus design	
	β	t-ratio	β	t-ratio	β	t-ratio	β	t-ratio	β	t-ratio	β	t-ratio	β	t-ratio	β	t-ratio
Constant (α)	1.88	6.01*	1.02	3.68*	-0.33	-1.12	0.78	2.91*	1.75	6.06*	-0.66	-2.37*	-0.96	-2.49*	1.32	4.69*
Zone	-0.17	-2.11*	0.30	3.76*	-0.34	-3.58*	0.17	1.90*	-0.60	-6.73*	0.73	6.98*	0.13	1.40	0.67	7.56*
Age	-0.01	-3.20*	-0.01	-1.05	-0.01	-1.43	-0.01	-0.83	-0.01	-1.66	-0.01	-1.31	-0.01	-1.69	-0.03	-1.84*
Gender	0.13	1.23	-0.14	-1.26	0.18	1.50	0.03	0.26	-0.25	-2.26*	-0.07	-1.57	0.28	1.89*	-0.16	-1.44
Occupation	0.01	2.12*	-0.21	-1.78*	-0.12	-1.91*	0.01	2.11*	-0.12	-2.00*	0.16	1.39	0.02	2.13*	0.13	1.14
Monthly income	0.01	2.16*	-0.01	-1.77*	-0.01	-2.74*	-0.01	-1.20	-0.01	-1.80*	-0.01	-1.83*	-0.01	-2.10*	-0.01	-0.16
Family size	-0.08	-2.63*	-0.02	-0.60	-0.04	-1.51	0.01	0.20	0.01	0.44	-0.02	-0.63	-0.03	-0.82	-0.01	-0.57
Mode	0.42	3.26*	0.10	0.77	0.40	2.71*	0.23	1.90*	-0.11	-0.92	0.33	2.57*	0.69	3.87*	-0.14	-1.82*
Bus fare	0.01	-1.81*	-0.01	-0.86	-0.01	-4.12*	-0.01	-0.46	0.01	2.27*	0.01	1.67	-0.01	-2.32*	0.01	1.69
No. of bus transfer	-0.02	-1.23	0.09	1.35	0.13	2.13*	0.02	2.33*	-0.06	-1.72	0.17	2.60*	0.18	2.36*	-0.03	-1.54
Bus travel time	0.01	1.31	-0.01	-0.04	0.01	1.35	0.01	2.06*	-0.01	-1.45	-0.01	-0.02	-0.01	-1.54	0.01	1.69
Bus waiting time	-0.01	-2.55*	-0.02	-3.80*	-0.01	-1.75	-0.03	-6.56*	-0.01	-1.72	-0.02	-4.99*	-0.01	-1.79*	-0.01	-2.11*
Trip purpose	0.19	1.31	0.13	1.97*	-0.16	-1.83*	0.06	0.44	-0.12	-0.86	-0.06	-0.42	0.02	0.14	0.01	0.08
Threshold values																
μ(1)	2.03	15.88	2.13	25.86	0.94	12.98	1.84	22.93	1.56	19.29	1.92	22.121	0.77	9.522	1.69	20.68
No. of observation	648		648		648		648		648		648		648		648	
Log likelihood	-466.6787		-516.9209		-518.3513		-556.8164		-529.2462		-494.2906		-352.0520		-527.8281	
Restricted log	-493.3246		-544.2455		-553.4513		-589.9366		-601.0583		-588.9946		-378.3715		-592.3849	
Chi-squared	53.29175		54.64906		70.20009		66.24049		143.6242		189.4079		52.63896		129.1136	
Degree of freedom	12		12		12		12		12		12		12		12	
R-squared	0.910		0.892		0.862		0.897		0.924		0.909		0.890		0.874	

* Statistically significant variables (p = 0.05

Zone: *0 if inner, 1 if intermediate, 2 if outlying;* **Age:** *continuous value;* **Gender:** *1 if male, 0 if female;* **Occupation:** *1 if employee (workers) and student, 0 otherwise;* **Monthly income:** *continuous value;* **Family size:** *continuous value;* **Mode:** *1 for bus users and 0 for taxi users;* **Fare:** *taxi fare minus bus fare for a given distance;* **Trip purpose:** *1 if work and edu., 0 otherwise;* **No. of bus connections (transfers):** *continuous value;* **Travel time:** *in-bus minus in-taxi time;* **Waiting time:** *bus minus taxi waiting time* are on time or available when needed. On the other hand, long waiting time is negatively related to schedules and has a coefficient of -0.03.

Transfers: This is one of the dependent variables with which travelers show a high level of dissatisfaction. Bus transfer is the convenience of making connected trips. Most trips in Addis Ababa cannot be made on a single bus because of city structure and the locations of activities. From Table 2 residents of outlying areas show less satisfaction with service transfers because the coefficient of zone is -0.60 and it is statistically significant. Male respondents, workers, students, and high monthly income earners also show dissatisfaction with bus transfers because their coefficients are negative and statistically significant. A surprising result is that travelers who pay high bus fares show satisfaction with service transfers because the coefficient of bus fare is positive and statistically significant. A possible explanation for it is that in Addis Ababa the fares are based on mileage so this finding implies that those making single long trips are satisfied with fewer transfers than those making connected shorter trips. This may be because there are more buses serving long trips than there are buses for shorter trips thus making transfers easy.

Frequency: The table shows that inner zone residents are not satisfied with frequency because the buses do not arrive as scheduled. Alternatively, it shows that for those living in outlying areas, the buses are on schedule and riders are satisfied with the frequency of bus services. This is because the coefficient of this variable is 0.73 and being statistically significant, it shows that where travelers live has a major effect on satisfaction with bus frequency. This finding also suggests that there is less supply of bus services in the inner part of the city. In addition, the coefficient of monthly income is negative and statistically significant suggesting that high monthly income earners are dissatisfied with bus service frequency possibly reflecting their preference for short waiting times. However, bus users (with a coefficient of 0.33) and travelers with many transfers (with a coefficient of 0.17) are satisfied with bus frequency.

Boarding Convenience: Residential location is statistically insignificant in the boarding convenience equation whereas male respondents, workers and students, frequent bus users, and travelers whose trips involve many transfers have positive and statistically significant coefficients. On the other hand, the higher the bus fare the lower the satisfaction with boarding convenience. Additionally, with coefficients of -0.01 respectively, high income earners and travelers with longer waiting times are dissatisfied with boarding convenience.

Bus Design: Few independent variables have statistically significant coefficients in the equation for bus design. The coefficient of outlying city residents is 0.67, and that of age is -0.03. These results show that older people express dissatisfaction with bus design as do bus users, and travelers with longer waiting times. For older people, this dissatisfaction could reflect their inability to step on/off the buses. Unlike European and American low step buses, those in Addis Ababa have high steps making them difficult for older people to board and alight.

Binary Logit Model Results

The estimated results of the public transport choice model are in Table 3. The model has a predicted outcome of 81.75%, a log likelihood ratio of 0.36, and a coefficient of determination of 0.89. It shows that most of the independent variables have significant effects on the choice of a bus over a taxi. Particularly, residents of outlying areas have a higher probability of choosing a bus according to the results because their coefficient is positive and statistically significant. This result is because buses are a more affordable means of transportation for long trips. In the inner city, trips tend to be short and using a taxi is a reasonable option. On the other hand, the coefficient of gender is negative and statistically significant showing less probability of men using buses. Contrariwise, it shows a higher probability of female respondents using buses compared to men, a result which reflects the fact that women use this mode predominantly for shopping trips (Figure 5).

Table 3: Binary Logit Results for Choosing Buses Over Taxis

Variables	β	**Marginal effect****	**t-ratio**
Constant (**α**)	0.4947	0.0457	1.6359
Zone: *0 if inner, 1 if intermediate, 2 if outlying*	2.0861	0.1927	7.5189*
Age*: continuous value*	-0.0189	-0.0018	-1.6956
Gender: *1 if male, 0 if female*	-0.3067	-0.0283	-1.8007*
Occupation: *1 if employee(workers) and student, 0 otherwise*	0.4386	0.0405	1.4542
Monthly income: *continuous value*	-0.0018	-0.0002	-5.2512*
Family size: *continuous value*	0.0696	0.0064	1.9008*
Trip purpose: *1 if work and edu.,0 otherwise*	0.5458	0.0504	1.3524
No. of bus connections (transfers): *continuous value*	-0.0629	-0.0058	-1.6854
In-vehicle time: *Continuous value (differential of bus and taxi travel time)*	0.0403	0.0037	4.7457*
Waiting time: *Continuous value (differential of bus and taxi waiting time)*	-0.0370	-0.0034	-3.5524*
Fare: *Continuous value (differential of taxi and bus fares for the specified distance)*	0.0045	0.0418	1.9960*
Dep. variable: MODE; Log likelihood function: -202.8043; Restricted log likelihood: -318.1553;Chi-squared: 230.7020; Deg. of freedom: 11; *Sig. level: 0.05; Pred. outcome: 81.75%, R^2=0.89, ** Marginal effect for Prob=1 (choosing bus)			

Another significant factor affecting the choice of bus as a mode is monthly income; higher income reduces the probability of using a bus reflecting the general nature of bus transportation as an inferior mode. This is because as income increases, affordability grows and travelers look for a more convenient, yet costly, mode of transportation such as a taxi or a private car for trips. Also, family size is positively related to mode choice according to the results in Table 3. As family size increases, the probability of choosing a bus increases, and as waiting time increases, the probability of choosing a bus reduces. The finding about waiting time implies that bus service frequency is an important factor in determining mode choice. Additionally, the larger the bus travel time relative to taxi travel time, the higher the probability of choosing a bus. Finally, the results show that the difference between taxi and bus fares significantly affects the choice of the bus for trips. As this difference increases, the probability of choosing a bus increases.

Influence of Satisfaction on Mode Choice

The impact of riders' level of satisfaction on the choice of public transport is shown in Table 4. In this table, a white dot (○) represents a positive relationship between the dependent and independent variables whereas the dark dot (•) represents a negative relationship. The (X) mark denotes a statistically insignificant variable. From the table, a clear relationship between the satisfaction parameters and mode choice can be seen. For example, male respondents have less probability of choosing a bus over a taxi (negative coefficient in the mode choice model). The reason could be that they are generally not satisfied with the attributes of the bus service such as bus transfers (referring to its negative coefficient in the satisfaction model). The table also shows that low-income groups generally express higher levels of dissatisfaction with bus services but still use them mainly because economic factors do not allow them to use taxis or private vehicles. Other variables, such as age, family size, occupation, bus waiting time, and travel time also explain the impact of level of satisfaction on mode choice.

Table 4:Impact of Citizens' Level of Satisfaction on Public Transport Mode Choice and Policy Response

Parameters	PT mode choice	Perception Model of Bus Condition								POLICY RESPONSE
		General satisfaction	Drivers behavior	Bus stop facilities	Schedule	Bus linkage	Bus frequency	Boarding convenience	Bus design	
Zone	○	●	○	●	○	●	○	**X**	○	Well integrated bus routes with good bus stop shades
Age	**X**	●	**X**	**X**	**X**	**X**	**X**	**X**	●	Bus transportation with special focus for the elderly
Gender	●	**X**	**X**	**X**	**X**	●	**X**	○	**X**	Transportation integrated with land use (for shopping trips)
Occupation	**X**	○	●	●	○	●	**X**	○	**X**	Peak-hour (rush hour) demand responsive bus transportation
Monthly income	●	○	●	●	**X**	●	●	●	**X**	Affordable bus transportation for the urban poor
Family size	○	●	**X**	**X**	**X**	**X**	**X**	**X**	**X**	Increasing public transportation mode choices
Travel time	○	**X**	**X**	**X**	○	**X**	**X**	**X**	**X**	Service coverage to the urban expansion areas
Waiting time	●	●	●	**X**	●	**X**	●	●	●	Adding public transport modes (BRT, LRT etc)
Trip purpose	**X**	**X**	○	●	**X**	**X**	**X**	**X**	**X**	Well managed bus stop facilities for daily users
Fare	○	●	**X**	●	**X**	○	**X**	●	**X**	Evaluation of bus pricing
No. of bus transfers	**X**	**X**	**X**	○	○	**X**	○	○	**X**	Well integrated buses with other public transportation modes such as BRT and LRT

○ = *Positive relationship between the dependent and independent variables*
● = *Negative relationship between the dependent and independent variables*
X = *Statistically insignificant variables (t-value below the critical)*

Figure 6: Trip Rate (Trips per Day)

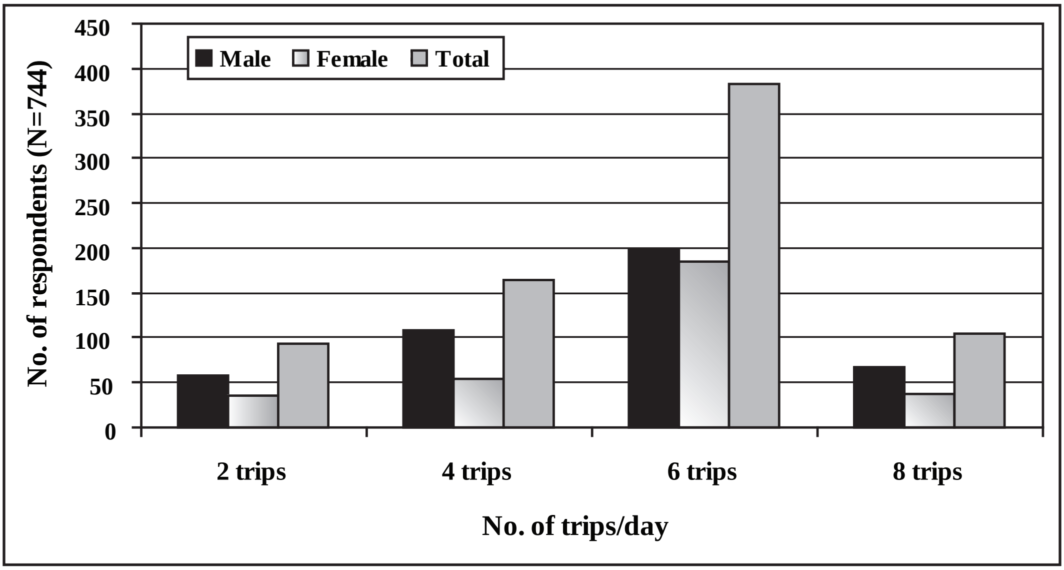
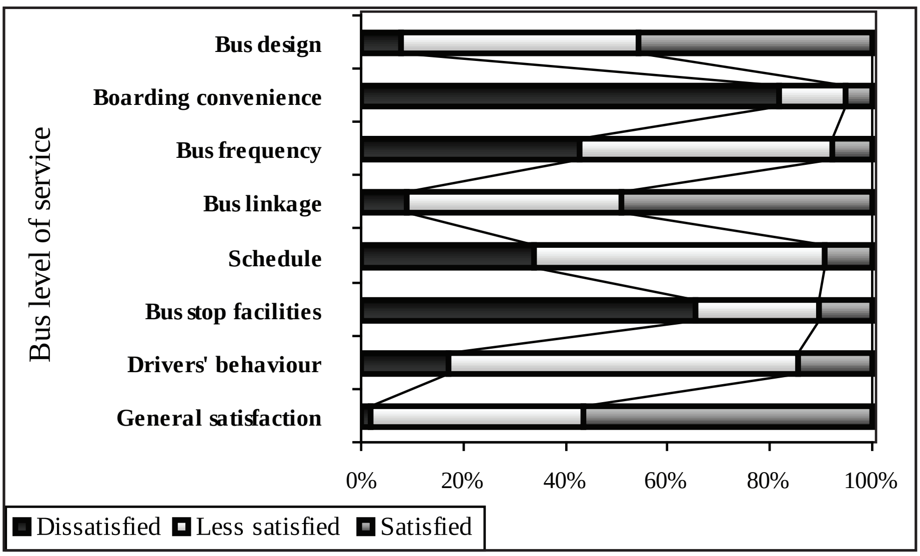


Figure 7: Satisfaction with Specific Bus Service Attributes



POLICY RECOMMENDATIONS

Based on the ordered and binomial logit modeling results, some policy directions can be provided to improve traveler satisfaction. For instance, the results show that older people show higher levels of dissatisfaction with existing bus services. Because such people are low-income earners it is difficult for them to afford private vehicles or a demand responsive taxi service commonly known in Addis Ababa as contract taxis. These taxis operate on fixed routes and charge more for route deviation, and because they are expensive, very few elderly people use them for their trips. Additionally, bus entrances and exits have high steps, which are difficult for older people to use without help from others. Therefore, providing a convenient and less costly public transport service and operating buses whose designs are sensitive to the needs of older people are of the essence.

It was also found that when income increases the probability of using a bus decreases. This implies that relatively high-income earners use more expensive means of transportation, such as taxis or private cars. However, because most people are poor only few of them can afford private cars. Limited employment and very low wages paid by employers especially for laborers are the main causes of the low incomes. Income data from the Central Statistics Authority (1997) reveals that 41.5% of households in Addis Ababa earns less than 4100 Ethiopian Birr (ETB) per year (about 342 ETB per month [1ETB=0.11USD]), 19.6% earns 4200 to 6599 Birr per year (350 to 550 ETB per month), and about 50% lives below the poverty line. Household expenditure continues to exceed income for those who earn between 3400 and 4199 birr per year (284 to 349 ETB per month) (Central Statistics Authority 1997). The urban poor depend upon public transport as they have no access to private vehicles. Yet, the quality of public transportation is poor in terms of service and coverage. Therefore, the provision of affordable transport for the urban poor (expanding public transport options), and the planning and designing of transportation so that it can generate economic and employment activities are important policies.

The mode choice results showed that females have higher probabilities of choosing the bus over other modes of transportation. Since their non-work trips (refer Figure 5) are not as time restricted as work trips, they prefer buses as a means of transportation. The complexity of their travel patterns calls for a well-linked public transportation system. Moreover, their complex household and caretaking responsibilities usually require them to make multiple stops on their trips which often make it costly for them as they must pay multiple fares for trips with multiple destinations. To reduce these trip costs, a well-designed public transport service with good connections to businesses and public facilities is needed.

On a general note, the findings regarding travel time, service frequency, family size, trip purpose, etc. provide directions for policy. Expanding existing networks and increasing the number of buses could increase users' satisfaction with service. This expansion is needed especially to serve outlying areas, which this study shows lack bus service coverage compared to the center city (Mintesnot and Takano 2006). This is necessary to satisfy the high demand for public transportation.

CONCLUSIONS

This research shows the importance of including satisfaction variables in mode choice analysis. The results show that the level of satisfaction has a significant influence on the probability of choosing a bus for trips. It was found that, in some cases, travelers continue to use the bus services even if their levels of satisfaction with some service attributes are low because they lack options for their trips. To increase satisfaction level and use of public transportation, the study recommends policies that emphasize public transport for the urban poor and the old, and that are particularly sensitive to female trip-making needs, as well as overall improvements in public transportation. Analyses of satisfaction with specific bus service attributes as dependent variables can increase the flexibility of bus service improvement and policy endeavors. Moreover, this research suggested application of simultaneous logit as a mode choice model. Usually mode choice is considered as an endogenous variable to be explained by independent variables. This paper extends the inclusion of mode choice as an exogenous variable to explain satisfaction.

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