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BUS RIDERSHIP ANALYSIS IN AMMAN CITY

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Abstract: This study is aimed at analyzing public transportation system within the urban area in Amman, the capital city of Jordan. Amman is having increased growth in population and private auto ownership resulting in congestion which is becoming one of the most frustrating daily problems encountered by most commuters. This increased growth n both population and auto ownership is accompanied with a stigma that is commonly attached to public transit users, in which most commuters prefer to use other modes of transportation in their daily trips. This research work investigated public bus system in Amman City in order to search for the factors that have impact on bus ridership. A survey was collected from 1532 respondents in Amman City in order to find the most important factors affecting the choice of mode of transportation among commuters. Binary logistic regression model was used to model the ridership of bus users. Results of this research work indicated that bus ridership is significantly affected by work trips, income, and private vehicle ownership. It was found that the main riders of public transport users are those whose trip purpose is work, families with low monthly income and those with no private vehicles owned.

Keywords: Bus ridership, logistic regression, Middle East, Survey.

1. Introduction

Mobility is an essential requirement for any type of meaningful involvement in our modern society. Without some form of adequate transportation, it would not be possible for individuals to shop, to socialize, to work, to worship, or to participate in many other activities (Hough et al. 2002). Moreover, over the last two decades there has been an increased concern with the decline in air quality, increased congestion, and negative impacts to the environment resulting from patterns that are favorable to the automobile (Badoe and Miller, 1999). As a result, improving urban transit services in ways that increase the competitiveness of transit relative to the private automobile and which reduce the growth in car dependence are desirable.

Developing countries in general experience a continuous change in the frameworks in which the urban transport sector exists, and often change rapidly. One of the reasons for this change is because society itself is changing. In other cases, it is because a framework is lacking or contains inherent weaknesses that need to be adjusted (Finn 2011).

Jordan sets an example for framework change where the Land Transport Regulatory Commission (LTRC) of the national Ministry of Transport controls, manage and regulate all land transport services throughout the country. Due to a conflict between Municipality of Amman and Ministry of Transport, in 2007, all responsibility for urban passenger transport in Amman, including the regulatory role, was transferred to Greater Amman Municipality while LTRC continues to regulate services elsewhere in the kingdom.

The culture of public transportation in developing countries, including Jordan, is suffering from different factors that would affect the reputation of its usage. These factors may include mismanagement of transportation facilities, delay and time scheduling, randomness of routes and pathways, undefined bus stops, daily fluctuations of number of buses for every route, lack of planning studies that define important variables to predict number of vehicles required for every zone or route, etc. These factors would make people reluctant to use public transportation; instead they would prefer to own their private vehicles regardless of economical situations.

Limited studies have been performed to evaluate mobility in cities of developing economies, where most of the research found on mobility is done for developed countries and therefore the results obtained cannot be used to evaluate mobility in developed economies, given large differences between them, such as infrastructure, economic conditions and administrative capacities. To this end, this study is aimed at predicting the individual's likelihood to ride buses using logistic regression using socio-economic and travel behavior characteristics.

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2. Literature Review

Mobility in developing world is affected with many factors that include increased motorization where urban structure is incompatible with the increased motorization, as well as, high demand that exceed capacity of facilities accompanied with increased population, increased wealth, a life style that encourages car ownership, etc (Gakenheimer, 1999).

On the other hand, there is a great need for a more sustainable urban transport for the future because of environmental deterioration, growing energy crisis, and traffic congestion combined with financial constraints. Koushki et al. (1999) tested the transit management awareness of passenger needs due to what have been noticed of a general lack of up-to-date information on the assessment of customer satisfaction with current services and future needs in Kuwait and other Persian Gulf region. In order to determine levels of management awareness of passenger priorities, and passenger satisfaction with the current performance of the bus service, two structured questionnaires were developed; one of these questionnaires was filled by top and middle managers of the transit system; while the other questionnaire was filled by passengers. These questionnaires were performed over a 10-month period; their results indicated that 93% of bus riders in Kuwait were low income expatriates from 16 different nationalities.

A computer-based phone survey was conducted by De Palma and Picard (2005) in Paris area and suburbs in which 4137 person were questioned in order to study the impact of travel time on route choice for private and/or public transportation commuters and introduced an index that measures the preferences towards risk in choice, also, the impact of key socio-economic factors (gender, employment, purpose of trip, etc.) on the risk of choice were considered, a discussion of three alternative models was performed in order to remove the unrealistic assumption that all users select the shortest route.

Commuters of different occupations differ in their mode choice according to their departure time, hence value of time and work time flexibility differ among different sectors of careers; self-employed workers as well as professionals value their times highly and they have flexible schedules, where employees have rigid work schedules, but have a less value of time; consequently higher incomes enables people to pay out-of-pocket money to avoid inconvenient modes of transportation (Arnott et al. 1994), (Evans, 1992), (Cohen, 1987), (Small, 1983).

Transit ridership modeling is normally performed using either multivariate regression or discrete choice models. Ahmad and Puppim de Oliveira (2016) employed multivariate regression in an attempt to estimate the amount of transport (private and public) using a nationally representative household survey from the 98 largest Indian cities. In addition, they used binary logistic regression to model choices between motorized and non-motorized, and private versus public transport. Findings revealed that densification in Indian cities reduce the amount of transport as well as enhances the probability of using public transport. Small and medium sized cities predominantly use private transport, whereas large cities prefer public transport but lack non-motorized transportation. Moreover, income was found to be the most important determinant of the amount of transport and the use of motorized and private transport.

Abdel-Aty (2001) used an ordered probit model to explain the likelihood of using transit based on a stated preference survey in two metropolitan areas in California. The study investigated whether advanced transit information would increase the acceptance of transit, and to determine the types and levels of information that are desired by commuters. the results indicated that the frequency of service, number of transfers, seat availability, walking time to the transit stop and fare information are among the significant information types that commuters desire. Factors found to contribute to the likelihood of using transit given information was provided were: income, education, and commute time by transit and whether the commuter is currently carpooling.

Al-Shili and Sadeq (2003) presented a study to evaluate intercity ridership demand, evaluate the existing services and predict future ridership in Palestinian territories. An on-board survey of bus riders was conducted to identify variables that influence demand. They used a simple linear regression to model ridership demand using the following variables: population of the origin city, population of destination city, bus fare, and percent of employees at origin city and percent of higher education students at origin city.

Nkurunziza et al. (2012) analyzed individual commuter preferences towards a proposed bus rapid transit system in Dar-es-Salaam, Tanzania. A stated preference survey was conducted in an attempt to identify how commuters perceived and value the proposed service quality variables. They following variables were considered: travel time, travel fare, and comfort; where the results of the survey were analyzed using a binary logit model. The findings revealed that comfort was the most valued variable compared to travel time and travel fare.

3. Data and Methodology

3.1. Survey

A survey was conducted among citizens of Amman city in order to find out factors affecting their mode of transportation choice behavior.

Respondents were interviewed on bus stops all over Amman city where 1532 in person interviews were conducted and respondents were asked questions concerning their socio-economic characteristics as well as their travel behavior characteristics. The main purpose of this survey was to study the behavior of commuters especially those of public buses in order to estimate the factors that contribute in bus ridership.

The first part of survey attempts to better understand the individuals and household characteristics such as: gender, age, income, number of family members, type and location of work, number of family members above 18 years, preferred home-based-work travel mode, number of household's automobiles, distance between home and job.

The second part of the survey attempts to better understand the bus commuter's information such as: time to reach a bus stop, trip purpose, and travel time on bus. These questions are the variables of the models to be developed, in which bus ridership is assumed to be a function of variables used in the survey.

Questions concerning origin-destination exact location were excluded, since most of respondents have ignored these questions, Table 1 shows the variables included in the survey as well as the counts and percentages of responses obtained under each category of variables.

3.2. General description of survey answers

According to Table 1 the total interviewed sample had 29.5% females. In addition, 88.7% of interviewed people were above 18 years. Most of the interviewed persons were either employees or university students with percentages of 38.3 for each. Approximately 80% of the surveyed sample ride buses in their daily trips, 45.56% stated that they use buses daily for home-based-work trip. Regarding household size, more than 65% were members of households of six or more.

All interviewed individuals reported having at least one family member above 18 years old, 62% of interviewed sample have monthly income below JD 500, while less than 4% earned more than JD 1500 per month. Approximately 40.4% of sample has no autos owned by household, where 38.7% have only one auto owned by household. Regarding distance between home place and work place, 71% of individuals estimated the distance to be more than 3km, while 12% estimated the distance to be in between 2-3km.

Table 1
Variables included in the survey with counts and percentages obtained under each variable.

Variable	Categories	Count	Percentage
Place of residence	Don't Live in Amman	310	20.2
	Live in Amman	1222	79.8
Gender	Female	452	29.5
	Male	1080	70.5
Age	<18 years	1359	88.7
	≥18 years	173	11.3
Job	School	157	10.2
	University	587	38.3
	Employee	587	38.3
	Self employed	141	9.20
	Unemployed	27	1.80
	Other	33	2.20
City of Work	Amman	217	14.2
	Outside Amman	1315	85.8

Table 1
Continued

Variable	Categories	Count	Percentage
Work trip mode of transportation	Bus	698	45.6
	Shared cab	157	10.2
	Taxi	136	8.90
	Automobile	289	18.9
	Carpooling	34	2.20
	Work private vehicle	162	10.6
	other	56	3.70
Family members plus respondent	Alone	86	5.60
	1	25	1.60
	2	81	5.30
	3	143	9.30
	4	199	13.0
	5	269	17.6
	6	230	15.0
	7	258	16.8
	>7	241	15.7
Family members >18 years	1	263	17.2
	2	344	22.5
	3	303	19.8
	4	277	18.1
	5	169	11.0
	6	94	6.10
	7	78	5.10
	>7	54	3.50
Monthly household income, JD	<300	430	28.1
	300-499	522	34.1
	500-749	256	16.7
	750-999	111	7.20
	1000-1500	153	10.0
	>1500	60	3.90
Number of autos owned by household	0	619	40.4
	1	593	38.7
	2	231	15.1
	3	56	3.70
	>3	33	2.20
Home-based-work trip distance, km	<0.5	85	5.50
	0.5-1	83	5.40
	1-2	87	5.70
	2-3	188	12.3
	>3	1089	71.1
Ridership of public buses daily	Don’t ride	303	19.8
	Ride	1229	80.2
Time to access bus stop, min	<10	404	26.4
	10-15	277	18.1
	15-30	281	18.3
	>30	267	17.4
Bus trip purpose	School	107	7.00
	University	411	26.8
	Work	397	25.9
	Shopping	115	7.50
	Transfer to other mode	163	10.6
	Other	36	2.30
In bus trip length, min	30-44	400	26.1
	45-59	255	16.6
	>60	184	12.0

In the second part of the survey, those using buses in their daily trips were asked to give their answers. 26.4% estimated the time to reach the closest bus stop to be less than 10 minutes, while 17.4% answered as belonging to the category of more than 30 minutes. Bus was used in 26.8% of daily trips to university, where 26% used buses in their daily Home-Based-Work trips. Travel time by bus was estimated by 25.5% of individuals to be less than 30 minutes, and about 12% estimated the travel time by bus to be more than 60 minutes.

3.3. Binary logistic regression

The variables' data from the survey was analyzed using a random utility model. This type of models is considered the most used model for processing data from choice experiments in transportation research (Ben-Akiva and Lerman 1985; Louviere et al.2000). The assumptions made by the model are that travel decision makers encounter a utility maximization problem based on the cost and quality of service rising from using a given mode and the uncertainty of choosing the given mode (Ortuzar and Willumsen 1994).

In this research; the response variable, bus ridership, is a binary variable and the independent variables are categorical, and hence the logistic regression is a suitable technique to be used. Table 2 includes a detailed description of the statistically significant variables incorporated in the statistical analysis.

Binary logistic regression is a type of generalized linear models (GLM), which models how a binary response is dependent on a set of explanatory variables. The explanatory variables can be discrete, continuous or a combination (Shafique and Hato, 2015).

Consider these factors or explanatory variables be represented by $X=(X_1, X_2, \ldots, X_k)$ with observed value $xi=(x_{i1}, x_{i2}, \ldots, x_{ik})$ for a survey respondent. Let Y be the binary response variable where $Y_i=1$ if the respondent rides bus and $Y_i=0$ if otherwise. The probability (π) that the person i is a bus rider can be formulated as follows:

$$\pi_i = Pr(Y_i = 1|X_i = x_i) = \frac{exp(\beta_0 + \beta_i x_i)}{1 + exp(\beta_0 + \beta_i x_i)}$$

Or

$$logit(\pi_i) = log\left(\frac{\pi_i}{1-\pi_i}\right)$$
$$= \beta_0 + \beta_i x_i$$
$$= \beta_0 + \beta_1 x_{i1} + \cdots + \beta_k x_{ik}$$

4. Results and analysis

4.1. Variables and cross tabulations

In this research, we use cross tabulation and binary logistic statistical model based on the survey data to determine the various variables influencing passengers' willingness to use the bus service as described by the dependent variable bus ridership.

Table 2
Variables used in model, their Symbols, categories and coding

Variable	Symbol	Categories	Coding
Ridership of public buses daily	Y	Don't ride* Ride	0 1
Place of residence	X_1	Don't Live in Amman* Live in Amman	0 1
Gender	X2	Female* Male	0 1
Age	X3	≥18 years* <18 years	0 1

Table 2
Continued

Variable	Symbol	Categories	Coding
Job	X4	School University Employee Self employed Unemployed Other*	X4 X4-1 X4-2 X4-3 X4-4 X4-5
City of Work	X5	Amman Outside Amman*	1 0
Work trip mode of transportation	X6	Bus Shared cab Taxi Automobile Carpooling Work private vehicle Other*	X6 X6-1 X6-2 X6-3 X6-4 X6-5 X6-6
Family members plus respondent	X7	Alone 1 2 3 4 5 6 7 >7*	X7 X7-1 X7-2 X7-3 X7-4 X7-5 X7-6 X7-7 X7-8
Family members >18 years	X8	1 2 3 4 5 6 7 >7*	X8 X8-1 X8-2 X8-3 X8-4 X8-5 X8-6 X8-7
Monthly household income, JD	X9	<300 300-499 500-749 750-999 1000-1500 >1500*	X9 X9-1 X9-2 X9-3 X9-4 X9-5
Number of autos owned by household	X10	0 1 2 3 >3*	X10 X10-1 X10-2 X10-3 X10-4
Home-based-work trip distance, km	X11	<0.5 0.5-1 1-2 2-3 >3*	X11 X11-1 X11-2 X11-3 X11-4

Cross tabulation was used to analyze the responses of the respondents whether they use buses in their daily trips or not in order to find out the differences between these two groups as shown in Table 3. Respondents were divided into two groups: bus riders and not bus riders, where the interviewed sample had 80.2% of bus riders and the remaining 19.8% of not bus riders. As illustrated in Table 3, both groups do not differ in the fact that most of the riders belong to ages above 18 years old, where university students and employees were the categories that ride buses on a daily basis with percentages of 41.33% and 34.50% respectively, while the employees was the category with highest percentage of riding other modes of transportation with a percentage of 53.80% in the not bus rider group.

Regarding gender of riders, it can be seen in both groups that the majority of riders are males with percentages of 70.38% in bus riders group and 70.96% in not bus riders group, with a small higher percentage of females in the bus riders group.

Most of the respondents work in Amman with a higher percentage of bus riders who use the bus from outside Amman workers. The highest percentage of bus riders belong to families with 6 members, while an unexpected result was found in the not bus riders group were most of the respondents belong to families of 7 and more than 7 family sizes. Most of the respondents belonging to either group came from families with 2 members above 18 with percentage of 21.97% for bus riders, and 24.42% for not bus riders. As expected, most of the bus rider have monthly income below JD 500, while most of the not bus riders have monthly between JD 1000-1500. Regarding number of autos owned by household, most of the bus riders group has at most 1 auto, while those belonging to not bus riders have mostly 1 or 2 autos owned. Finally, most of the respondents in the two groups have their daily work trips for distances longer than 3 km.

Table 3
Cross tabulations of survey responses related to bus ridership

Variable	Categories	Ride bus, %	Don't ride, %
Gender	Female	26.62	29.04
	Male	70.38	70.96
Age	≥18 years	97.69	86.49
	<18 years	2.31	13.51
Job	School	12.04	2.97
	University	41.33	26.07
	Employee	34.50	53.80
	Self employed	8.62	11.55
	Unemployed	1.55	2.64
	Other	1.96	2.97
City of Work	Amman	84.05	93.07
	Outside Amman	15.95	6.93
Family members plus respondent	Alone	6.83	0.66
	1	1.55	1.98
	2	5.94	2.64
	3	10.17	5.94
	4	14.00	8.91
	5	21.00	4.62
	6	17.01	6.93
	7	12.69	33.66
	>7	11.07	34.65
Family members >18 years	1	19.93	5.94
	2	21.97	24.42
	3	18.80	23.76
	4	13.75	19.14
	5	11.15	10.56
	6	5.78	7.59
	7	4.72	6.60
	>7	3.91	1.98
Monthly household income, JD	<300	34.17	3.30
	300-499	40.11	9.57
	500-749	15.79	20.46
	750-999	4.96	16.50
	1000-1500	3.82	34.98
	>1500*	1.14	15.18
Number of autos owned by household	0	48.33	8.52
	1	36.78	46.53
	2	10.50	33.66
	3	2.93	6.60
	>3*	1.46	4.95
Home-based-work trip distance, km	<0.5	6.92	0.00
	0.5-1	5.70	3.30
	1-2	5.70	5.61
	2-3	14.48	3.30
	>3*	67.21	86.80

4.2. Bus ridership

The collected data from the 1532 surveys was divided into two samples: a training sample which is used to train the model and a testing sample which is to validate the model developed using the training sample. The results are summarized in the following sections.

4.2.1. Modeling of bus ridership

Seven hundred and sixty six survey data was used to develop a binary logistic model in order to predict ridership of buses. SPSS v.21 was used for model development and analysis; the results of the best model obtained are described herein.

As shown in Table 4, the omnibus tests of model Coefficients table gives the result of the Likelihood Ratio (LR) test which indicates that the inclusion of these variables contributes significantly to the developed model fit. A p-value (sig) of less than 0.05 for the model means that the model is a significant improvement to a model with a constant only.

Table 4
Omnibus tests of model coefficients.

Chi-Square	Degrees of freedom (df)	Sig
372.615	8	0.000

From Table 5, we can conclude that 66.8% of variation in bus ridership can be explained by the model developed, where the correct classification rate obtained using this model is 93%.

The p-values are all below 0.05 which means that all included variables in the model are significant. The model results indicates that using a bus for work trips (X_6) increases the odds of riding a bus by 585.688 times more than other going to work using other modes of transportation. The results obtained indicate that riding a bus for work trips is the most important variable in the bus ridership model.

The second most important variable that was found to affect bus ridership and hence increases the likelihood of an individual to use bus service is when the family does not own an automobile (X_{10}) with 39.169 times to more likely ride a bus than families that own more than 3 automobiles. A less effect on ridership was found when the monthly income is between JD 500-749 (X_{9_2}) and when the monthly income is below JD 300 (X_9), with 11.693 and 10.268 times respectively more likely to use a bus than families with a monthly income of more than JD 1500.

The variables with the lowest contribution to bus ridership were in order of importance: when the number of family members was 5 (X_{7_5}) and 6 (X_{7_6}); when the individual uses his/her automobile for work trip (X_{6_5}); or when the individual uses a Taxi for work trip (X_{6_2}) with the following odds ratio respectively: 5.962, 4.469, 4.276, and 3.788.

To this end, variables that have the most significant effect on bus ridership were: daily work trip is by bus, families with no automobiles owned and monthly income below JD 749. Etminani-Ghasrodashti and Ardeshiri (2015) found that individuals lifestyle which includes leisure activities such as going to a club for exercise, strolling in malls and shopping centers for fun or going to natural gardens, due to the long distances, increases the likelihood of doing them by private car which is in accordance with findings herein, where daily work trips were found to increase the likelihood of riding a bus. In addition Taylor, et al (2009) also found that employment affects bus ridership.

Taylor, et al (2009) found that amongst other variables that car ownership was found to affect bus ridership which supports the findings found herein in which it was found that families with no vehicle owned increased the likelihood of bus ridership.

Moreover, results herein indicated that low income increases the likelihood of riding the bus; previous studies also reported the same result as found by Shaaban and Khalil (2013), Taylor, et al (2009) and Mujalli (2007).

Table 5
Model used for predicting bus ridership.

Predictor variable	Coefficient	S.E	P-value	Exp (B)	95% C.I. for EXP (B)	
					Lower	Lower
Constant	-2.586	0.383	0.000	0.077		
X_6	6.373	1.059	0.000	585.688	73.455	4669.914
X_{6_2}	1.332	0.490	0.007	3.788	1.449	9.903
X_{6_5}	1.453	0.494	0.003	4.276	1.632	11.266
X_{7_5}	1.785	0.509	0.000	5.962	2.199	16.165
X_{7_6}	1.497	0.489	0.002	4.469	1.715	11.645
X_9	2.329	0.478	0.000	10.268	4.021	26.220
X_{9_2}	2.459	0.435	0.000	11.693	4.989	27.407
X_{10}	3.668	0.414	0.000	39.169	17.385	88.246
-2 Log likelihood	285.632					
Nagelkerke R2	66.8%					
Classification rate	93.1%					

4.2.2. Validation of Prediction Error Rate

The reliability of the prediction error rate observed in the training sample was examined by applying the chosen prediction rule to a validation sample as illustrated in Table 6. The new prediction error rate is about the same as that for the training data set, then the latter gives a reliable indication of the predictive ability of the fitted binary logistic regression model and the chosen prediction rule.

In the current study, the fitted logistic response function based on the training sample given in Table 5 was used to calculate the estimated probabilities for the 766 cases of validation sample. The chosen prediction rule is applied to the estimated probabilities as predict 1 if $\pi_i \geq 0.5$ and predict 0 if $\pi_i < 0.5$. The percent prediction error rate for the validation sample given in Table 6 is 85.6 while the rate for the training sample was 93.1. Thus the total prediction error rate for the validation sample is not considerably higher than the training sample and it can be concluded that it is a reliable indicator of the predictive capability of the fitted logistic regression model.

Table 6
Predicted classification table based on training sample and validation sample taking 0.5 as cutoff.

Training sample				Validation sample			
Observed (Y)	Expected (Y)			Observed (Y)	Expected (Y)		
	0	1	% correct		0	1	% correct
Do not Ride bus (0)	90	28	76.3	Do not Ride bus (0)	150	35	81.1
Ride bus (1)	25	623	96.1	Ride Bus(1)	75	506	87.1
Overall percentage			93.1	Overall percentage			85.6

5. Conclusions

The main objectives of this research work were to find out the factors that have the most significant effect on bus ridership in Amman City using socio-economic and travel behavior characteristics. Work trips commuted by bus were found to have the highest positive impact on bus ridership. It was also found that the bus riders are more likely to be those belonging to families with low-income, which has created a poor local image of the service and driven other population categories away from using the service. In addition, low vehicle ownership was found to increase the probability of riding buses.

In order to encourage public buses riding, public buses need to be improved in order to compete with other modes of travel such as private cars and taxis. Emphasis on improving the image of buses should be a priority.

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