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Modelling Switch-Behaviour of Own Car vs. Public Transport Modes for Work & to Study Trips

Case Study: Tripoli - Libya

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Abstract:

This research deals with estimating the likely switch of own car and private vehicles modes users to public transport modes in the main cities as Tripoli Capital city of Libya due to reduced travel time of all trips influenced by travel costs through the introducing the public transport modes such as public buses and increasing cost of car parking. The data on other factors (variables) that could potentially reason a model switch of from own cars and private transport to public transport were collected through a survey (questionnaire) with a specified preference approach. Mode-switch models to describe the switch of behaviour of own car operators to public transport are developed. A binary logit regression model was used to assessment the transport displacement model for work and study trips. Mode-switch likelihood curves have also, been developed to serve as a user-friendly tool to analyse the likely model-switch for a variety of variables. One way to achieve this objective is by establishing reserved public transport lanes on main urban Tripoli city roads. The providing of private road lanes will reduce the level of road traffic congestion and this may effect in a switch of all or some private transport mode users to public transport modes.

Key words: *Own car, Public transport modes, logit model, Travel time, Travel cost, parking cost and switch probabilities.*

Introduction:

The own cars are considered one of the significant modes of private transport vehicles in Libyan all cities and especially in Tripoli, as it is more reliable than the available private transport modes options such as (private taxi and micro coach) (Amirodin &adel 2011). This research describes and presents the results from the data collected analysis of data on own car

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and private transport such as private taxi, microbuses and coaches users, with acomprehensive description of the statistical tests used in this research to estimate the suitability of the model parameters and the overall goodness-of-fit of the model. these outcomes are presented abinary logit model is presented for own car versus public transport as alternative transport modes for daily work and study trips, with the objective to compare the utility of the two to understand why own car users in main Tripoli city roads are reluctant to take the taxi and microbuses. The likelihood of own car users switching to public transport modes was also examined based on scenarios of reducing the public transport travel cost, travel time, and increased car parking fee.

Problem statement and Study Area:

The own cars are considered one of the most accessible means of transportation modes in Libyan cities, which commuters can rely on to meet their daily travelling needs. There are many reasons that lead residents of Tripoli city to prefer using their own cars for all their trips, whether for work, study and shopping trips, and also why these cars are more popular than other private transportation options available in Tripoli. In summary, because the own cars are readily available, reliable, comfortable, convenient and safe, they symbolize power, status and prestige and provide a convenient means of travel for all daily journey and purposes (Alrabotti 2007). The increase in the number of own cars on the Tripoli city streets has led to a significant rise in road traffic congestion, which results in longer travel times for all trips, air and noise pollution and traffic accidents.

Methodology:

The survey was conducted through questionnaires on selected roads in Tripoli city, where the movement of available private vehicles, such as (own cars, taxi, minibuses, and private coaches) is higher the the available public transport vehicles. The survey employed a questionnaire to gather important information and data. The targeted respondents in this research are users of private vehicles who move around the area of the study and use their vehicles for daily tripsto work and study. Road users in Tripoli streets were randomly selects. To analysis this questionnaire and obtain the best outcomes that highlight the issue, the Statistical Package for Social Science software (SPSS) and

Microsoft Excel 2007 software were utilized and a binary logit model for public transportation alternatives was developed.

Mode Switch Model, Own car vs. Public Transport:

The binary logistic model was developed for own car use versus public transport modes for daily trips (to work and to study), to examine the factors influencing own car/public transport usage and to predict the likelihood of switching from own car to public transport modes as affected by reduced travel time and travel cost, and own car ownership.

The models examined public transport characteristics and own car journeys as travel cost, travel time, personal information and socio-economic features to determine their effect in the choice of appropriate transportation mode. In the models, the dependent variables were “1” for public transport usage and “0” for own car usage. The descriptive variables for trips-work and study were included: monthly income, own car ownership, age, household size, travel time, travel cost. To estimation the case, the own car was considered as the baseline case. Thus, a positive coefficient for a variable in in the select of own car shows an increase in the use of public transport mode, but a negative coefficient for a variable in the select of own car shows a decrease in the use of public transport- the higher negative rate shows the lower use of public transport modes.

Data Analysis and Results Discussion:

1- Mode Switch Model: Own Car vs. Public Transport for Work-Study Trip:

The binary logistic regression was used to estimate the transport mode model switch for work and study trips. Before examining the model for work and study, the data was divided into estimation sample and hold-out sample (for model validation as according to Blattberg et al 2004). Consequently, 750 samples were selected for model estimation. The mode switch was considered as the dependent variable, with 0 = car, and 1 = public transport. Several models namely (binary logistic models) were analysed and the outcome of the best model is presented as in Table 1.

Table 1 Shows the Binary logistic model estimation for public transport shift under work and study trips (n = 750 samples)

Variable	Coefficient	S.E.	Df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Age	-1.134	0.195	1	0.000	0.322	0.22	0.471
Household size	1.004	0.219	1	0.000	2.73	1.776	4.196
Travel time	-1.274	0.167	1	0.000	0.28	0.202	0.388
Travel cost	1.103	0.21	1	0.000	3.013	1.998	4.544
Income	-1.126	0.144	1	0.000	0.324	0.245	0.43
Car ownership	-1.633	0.259	1	0.000	0.195	0.118	0.324
Constant	7.622	1.197	1	0.000	2042.9		
Summary of statistics							
-2 Log likelihood	320.472						
Chi-square	717.323		6	0.000			
Cox & Snell R Square	0.616						
Nagelkerke R Square	0.822						
No. of observation	750						

Dependent variable: 1 = Public transport, 0 = Car

The table (1) illustrate the significant attributes namely age, household size, travel time, travel cost, income and car ownership with 0.0000 significant levels.

By Abuhamoud 2012, Bajracharya 2008, Dayton 1992 and Essia 2009, that according to the binary logistic likelihood model equation contains only two mode options and the model is rewrite as in Equation (1).

$$P_a = \frac{1}{1 + e^u} \quad (1)$$

Where

= probability of own car users' switch to public transport modes P_a

= utility function for public bus mode u

= the base of natural logarithms (approximately 2.718). e

The research utility function for public transport modes presented as in Equation (2).

$$U_b = \beta_0 + \beta_1 X_{Age} + \beta_2 X_{Hd} + \beta_3 X_{TT} + \beta_4 X_{Tc} + \beta_5 X_{Inc} + \beta_6 X_{no} \quad (2)$$

Where

= utility function for public bus mode U_b

= the constant of model specific β_0

$\beta_1,\beta_2,..,\beta_6$ = coefficients of associated with explanatory (significant) variables

all this variables are denotes individual explanatory $X_1, X_2,..,X_6$

= age of private vehicles users Age

= household size Hd

= travel time TT

= cost of trip travel (trip fee) Tc

= monthly income (salary) Inc

= car ownership per household (number of cars) no

Omnibus tests for the model coefficients produced a significant $p< .001$ with the chi-square value of 717.323 and df = 6 as introduced in Table 2. This is a test of the zero hypothesis, which states that adding independent factors to the model equation does not significantly increase its ability to forecast the decisions of the study subjects. Therefore, it is conclude that the present model coefficients are statistically significant.

Table 2 Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	717.323	6	.000
	Block	717.323	6	.000
	Model	717.323	6	.000

The statistics displayed from the model summary -2 Log likelihood (-2LL) stand at 320.47, with the Cox & Snell R^2 value at 0.616 and the Nagelkerke R^2 at 0.822 (close to 1) representing a strong of model correlation, which proposes a well-fitting model.

The interpretation coefficient of the logistic regression, which often provides clearer insights (especially for the dummy independent variables) is the “odds ratio”, exp(β), which is the effect of the independent variable on the probabilities ratio . In other words, the probabilities ratio is the likelihood of an event happening, divided by the likelihood of it not happening. Such as, if 95% C.I. for exp(β) 2 = (from 0.471/0.22, i.e., 0.471 likelihood of an event happening, 0.22 likelihood of the event not happening), then a unit change in X would make the event twice as likely (0.471/0.22) to occur.

As shown in Table 1, it was found that all the independent factors were found to have a significant influence on the transportation switch (p value less than 0.05). Age was identified as an important factor in determining transportation switch at 0.05 significant level ($p < 0.001$). The outcomes expression that Coefficient and Exp (B) values were -1.134 and 0.322 (95% CI: 0.22-0.471) indicating that older groups of age will tend to select car instead of public transport. It appears that a unit decrease in the group of age will increase the probabilities of a person switch into public transport modes by 3.11 times (that means maximum probabilities ratio value is equal to (1) divided on Exp(B) 0.322 as 1/0.322= 3.11 times). Moreover, household size was found to have a significant effect in transport switch ($p < 0.001$). A positive value of B, 1.004 as well as Exp(B) value of 2.73 proposes that a larger household size is likely to switch to public transport modes. More specifically, an increase of one unit in household group will increase the chances of switching to public transport by 173%, on the other hand, that means the likelihoods ratio of household size (2.73) is more than the value of the maximum likelihoods ration value (1), which cannot be stated as 273% but 173% as (2.73 - 1 = 1.73*100 = 173%).

Additionally, outcomes also illustration that travel cost and travel time were important forecasters for transportation switch at the significant level of 0.05. But Travel cost, has demonstrated the opposite direction of effect on transport switch (Coefficient = 1.103, OR = 3.013 (95% CI: 1.998-4.544)) compared to travel time (Coefficient = -1.274, OR = 0.28 (95% CI: 0.202-0.388)). As far as the travel cost is concerned, a unit increase in travel cost's group will increase the likelihoods of switching into public transport by the factor of 3.013. As a contradiction, a unit decrease in travel time will increase the likelihoods of switching to public transport modes by 3.57 times respectively (that means maximum likelihoods ratio rate equal (1) divided on Exp(B) 0.28 as 1/0.28= 3.57 times).

Therefore, regarding the combination of travel cost and time, the researcher concludes that for a higher travel cost, and shorter travel time, a person is most likely to switch to using public transportation modes. Furthermore, it was found that the influence of income also effects the transportation switch. The coefficient value of -1.126 together with odds ratio of 0.324 (95% CI: 0.245-0.43) shows that for higher monthly income groups, they are fewer likely to switch to public transportation modes. In other mean, a unit decrease in monthly income group will increase the odds of switching into public transportation modes by a factor of 3.1. Last but not least, the number of car ownership was found to significantly impact the transport switch (p < 0.001). Based on the table, Coefficient value was -1.633 with an odds ratio of 0.195 (95% CI: 0.118-0.324) which means that with each unit decrease in car ownership group, the respondents are 5.13 times more likely to switch to public transport. This finding shows that when the number of car owned increases, a person will tend to travel by car to work or study given that other factors remain constant. Also we confirm the expectation that increasing the travel cost of own car use may be an effective deterrent against own car use unless a suitable other mode of transport is provided (Arne et al. 2004; Kain& Liu 1996) did analysis an econometric of the factors influencing public transport user. It is understood from their results that public transport users will decrease by decreasing charges than by become better the service, although both changes will decrease own car use. Table 3 shows the Hosmer-Lemshow statistic that demonstrated the fit by dividing 10 ordered groups of subjects and then compares the number in each group (the observed) with the number predicted by the logistic regression model (predicted). Thus, the statistic is a chi-square statistic with a desired outcome of insignificance and indicates that the predictions form the model do not significantly differ from the observations. The likelihood-ratio test uses the maximum value of the the ratio of the likelihood function of the full model against the maximum value of the likelihood function of the simplified model. The model fit statistic is the Hosmer and Lemeshow statistic, calculated as two sum as $\sum_{cells}\frac{(O-E)^2}{E}$, where O and E are the observed and expected counts in a certain cell. To support model improvement,, the Hosmer and Lemeshow's goodness of fit test statistic is computed and summarised as shown in Table 3. The test demonstrated that the observed and estimated benefits do not differ insignificantly different (chi square = 7.018, 10 category groups times in 2 outcome categories = 20 cells) with an expected frequency of more than 5%, df = 10-2 = 8, p = 0.535) suggesting that the model fit is well. To provide graphical overlay of the model, figures 1 and 2 are presented. The model fit can be detected if the observed point extend beyond the expected fit line.

They mentioned how the model fits the data, the goodness-of –fit statistic was calculated using Hosmer and Lemeshow, and a chi-square test was performed between observed values (the values are researcher obtains empirically through direct observation) and expected values frequencies (the expected values based on a specific hypothesis) as shown in

Table 3. There was slight difference between observed and estimated values for both modes of transport, as indicated by the chi-square value, which was not statistically significant.

Table 3 Hosmer and Lemeshow's test for under work and study trip (n = 750 samples)

	Car		Public	Transport	
No.	Observed	Expected	Observed	Expected	Total
1	77	76.964	0	0.036	77
2	74	74.720	1	0.28	75
3	74	73.642	1	1.358	75
4	67	67.603	6	5.397	73
5	51	55.002	21	16.998	72
6	39	31.963	36	43.037	75
7	9	10.260	62	60.74	71
8	3	3.016	64	63.984	67
9	0	0.777	75	74.223	75
10	0	0.052	90	89.948	90
Chi-square	Df	Sig.			
7.018	8	0.535			

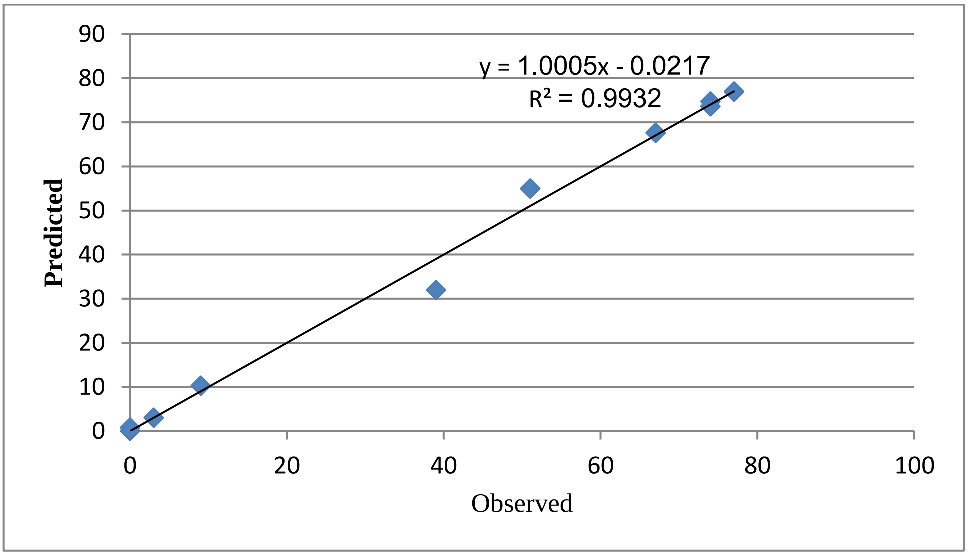

Figure 1 Observed vs. predicted by own car

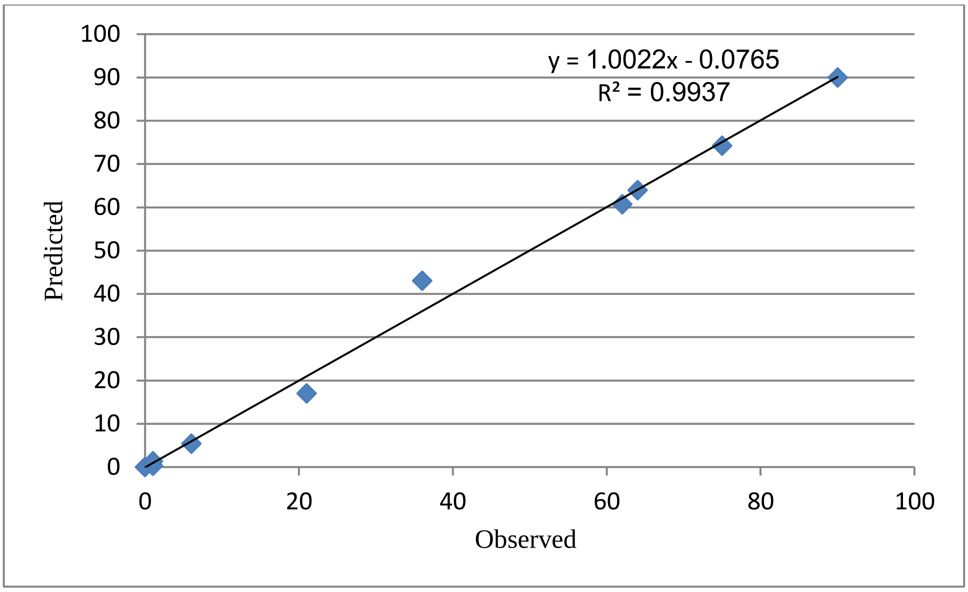

Figure 2 Observed vs. predicted by public transport

The values that were observed and were predicted were close; indicating that the model fits well (Figures 1 and 2). The Classification matrices are also calculated to evaluate the models agreement with the data as shown in Table 4. These metrics indicate the model classifies 100% of the car cases and 0.0% of the public transport cases. The predictions were accurate at 52.5%. This prediction are based on the model when it includes only the constant.

Table 4 Observed by all trips model for (car vs. Public transport) model under shopping trip (n = 750 samples)

Observed		Predicted		
		Car	Public transport	% Correct
Step 0	Car	394	0	100.0
	Public transport	356	0	.0
	Overall Percentage			52.5

The cut value is 0.50

Table 5 shows that the estimated logistic model has an overall success rate of 92.1% which is over the 25% relative accuracy according to the probability standards estimated at 62.7%. This indicates that this logistic model does a good job of distinguishing between the two groups. For own car users, 93.4% of respondents were correctly classified while 90.7% of public transport users were correctly predicted. Thus, the overall accuracy of 92.1% provides an insight into the models appropriate fit.

Table 5 Classification table for binary logistic model under work and study trip (n = 750 samples)

		Predicted		
		Car	Public transport	% Correct
Observed	Car	368	26	93.4
Step 1	Public transport	33	323	90.7
	Overall Percentage			92.1

proportional accuracy by chance 25% criteria = 62.7

2- Probability Prediction:

In this part, the estimated probability function was used with 750 samples generate the probability of transport switch. To obtain an expected response for each observation, you can apply a decision rule to the expected likelihoods. For example, you can classify a observation as positive if p̂>p̂' and of course, classify it as negative if the reverse is true. Note that this rule can be written as p̂>0.5. In this context, the samples were then classified into a group of own car and a group of public transport modes using cut off point of 0.5 (classification based on expected odds). The criteria uses a cut-off value of 0.5 to predict a binary outcome from expected odds I, meaning that the probability of primary outcome is similar to that of a secondary result. A cut-off point of 0.5 is not always acceptable, since the observed proportion of a primary outcome in a given population may not always be 50% (Shah 2012). A sample with probability of 0.5 or less will go to the cars group, while the samples exceeding 0.5 will go to the group of cars, while sample more than 0.5 will belong to the public transport mode's group. Accordingly, the predictive capability of the probability function for the holdout samples was evaluated using the classification table as shown in Table 6 below. As shown in the table, the probability function was able to predict 81.4% car users, while 96.9% of public transport users were predicted correctly. The overall hit ratio of 88.0%, which is far greater than the 25% proportional accuracy by chance of 63.8%, indicates that this probability function has good discriminate ability.

$$P = \frac{1}{1 + e^{(7.622 - 1.134*Age + 1.004*Hd - 1.274*TT + 1.103*Tc - 1.126*Inc - 1.633*no}} \quad (3)$$

Table 6 Classification table for work and study trip probability function

		Predicted		
		Car	Public transport	% Correct
Observed	Car	70	16	81.4
	Public transport	2	62	96.9
	Overall Percentage			88.0

Proportional accuracy by chance 25% criteria = 63.8

Conclusion:

This research examines the behaviour of transport users in Tripoli roads between two current transport modes available, namely private transport vehicles as (own car, taxi, minibuses) and public transportation vehicles, and it determines the switch to that commuters make when choosing their transport mode. The advantages of the current transport modes were compared to identify the important reasons behind the select of a particular mode and the circumstances that motivate commuters to leave their own cars. In order to encourage more use modes of public transport, this research examines the effect on own car use if the total public transport's travel time and cost were reduced and the outcomes encourage that travel time and travel cost are features that determine why own car in Tripoli roads use is a favoured mode of transport. This was understood through the analysis of the binary logistic equation of merit using options for multiple scenarios of travel time and cost for all trips> to encourage and support more private vehicles users to utilize public transport modes in the Tripoli city roads, and to be less dependent on own car, an efficient public transport system is clearly needed. The use of separate public transport lanes is among the initiative that can be proposed to improve the public transport system services in roads Tripoli. One of the traffic restriction polices is the use of road pricing policies such as London Road Pricing (Litman 2005), Ma laysia (Nurdden et al. 2007) and India (Arasan and Vedagiri P 2011) could further enhance a policy that encourages the use of public transport. The results of this study for both trips establish that the travel time, travel cost, car ownership and monthly income for both trips are the contributing factors that support and encourage users of private vehicles to switch from own car to public transport modes. The Need to redesign the current Tripoli planning area and re-establishment of public transportation system services are very important to reduce travel times for several types of trips and therefore will reduces traffic problems in city roads. All these factors supports the travellers to switch from private vehicles modes to public transport modes for all daily trips namely, to work and to study.

In conclusion, it is conclude that all the factors that play a significant role in switching commuters from private vehicles ownership to ride public transport modes are the decrease in travel time, decrease in travel cost, increasing cost on car parking spaces and decrease waiting time in the public transport stations. By improving those factors, a large fraction of respondents from the Tripoli city residential areas will switch to the public transport modes and contribute more to environmental protection and ecological balance.

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نموذج (نمذجة) سلوك التحول من السيارة الخاصة الى وسائل المواصلات العامة لرحلات العمل والرحلات الدراسية
حالة الدراسة: طرابلس – ليبيا

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الملخص:
هذا البحث يتناول تقدير التحول المحتمل لمستخدمي السيارات الخاصة الى وسائل النقل العام في العاصمة الليبية مدينة طرابلس من خلال خفض وقت السفر لرحلة والتعامل مع تكلفة السفر من خلال إدخال وسائل النقل العام وزيادة تكلفة مواقف السيارات الخاصة. تم جمع البيانات حول عوامل أخرى (المتغيرات) والتي قد تسبب في التحول من السيارات الخاصة الى وسائل النقل العام من خلال استبيانات المسح باستخدام النهج التفضيل المعلن. تم تطوير نماذج التحول لشرح سلوك التحول لمستخدمي السيارات الخاصة الى وسائل النقل العام وتم استخدام الانحدار اللوجيستي الثنائي في تقدير نموذج تحول النقل لرحلات العمل والدراسة. تم أيضا تطوير منحنيات احتمالية التحول لتكون بمتابه أداة سهلة الاستخدام لتحليل التحول المحتمل لمجموعة من المتغيرات. إحدى طرق تحقيق هذا الهدف هي من خلال إنشاء او تحديد حارات خاصة لحركة لنقل العام وتكون محجوزة على الطرق الحضرية الرئيسية بمدينة طرابلس. وتوفير مساحة كافية لطرق الحضرية، التي ينتج عنها تقليل درجة الازدحام المروري وقد يؤدي هذا الى التحول لبعض من مستخدمي المركبات الخاصة الى وسائل النقل العام.

الكلمات المفتاحية: *السيارة الخاصة، وسائل المواصلات العامة، نموذج الثنائي، وقت السفر، تكلفة السفر، تكلفة محطات الوقوف واحتمالات التحول.*