

# Modeling a Multinomial Logit Model of Intercity Travel Mode Choice Behavior for All Trips in Libya

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**Abstract**—In the planning point of view, it is essential to have mode choice, due to the massive amount of incurred in transportation systems. The intercity travellers in Libya have distinct features, as against travellers from other countries, which includes cultural and socioeconomic factors. Consequently, the goal of this study is to recognize the behavior of intercity travel using disaggregate models, for projecting the demand of nation-level intercity travel in Libya. Multinomial Logit Model for all the intercity trips has been formulated to examine the national-level intercity transportation in Libya. The Multinomial logit model was calibrated using nationwide revealed preferences (RP) and stated preferences (SP) survey. The model was developed for deference purpose of intercity trips (work, social and recreational). The variables of the model have been predicted based on maximum likelihood method. The data needed for model development were obtained from all major intercity corridors in Libya. The final sample size consisted of 1300 interviews. About two-thirds of these data were used for model calibration, and the remaining parts were used for model validation. This study, which is the first of its kind in Libya, investigates the intercity traveler's mode-choice behavior. The intercity travel mode-choice model was successfully calibrated and validated. The outcomes indicate that, the overall model is effective and yields higher precision of estimation. The proposed model is beneficial, due to the fact that, it is receptive to a lot of variables, and can be employed to determine the impact of modifications in the numerous characteristics on the need for various travel modes. Estimations of the model might also be of valuable to planners, who can estimate possibilities for various modes and determine the impact of unique policy modifications on the need for intercity travel.

**Keywords**—Multinomial logit model, improved intercity transport, intercity mode-choice behavior, disaggregate analysis.

## I. INTRODUCTION

OF late, the capability of forecasting and assessing the demand of intercity public transportation has become significantly crucial. As a developing country, in Libya, it requires this kind of project to establish the associations between travel demand and factors influencing it. Travel demand models are employed to predict the need for travel routines, as well as to identify the value, which individuals put on the numerous aspects, which influence their options. A

well-known instance is the problem of intercity mode choice, which represents choices of travelers among available travel modes. Mode choice is affected by numerous aspects including, the level-of-service attributes, subjective factors, land-use and accessibility, and personal and family features. The choice models associate the choices of travelers with the features of the available modes (such as, the time and fare of traveling to each city, reason of travel, LOS, and so on), the characteristics of trips, and the characteristics of the traveler (such as age, gender, and income). The models offer estimations of travelers' readiness, to spend for modifications in mode characteristics, such as LOS, travel time etc.

The most common difficulties for tourists and foreigners in unfamiliar areas are that, public transport is still not accessible. Moreover, the current transport system in Libya does not effectively meet the demand for the movement of goods and people. The 2017 Soccer African Cup, as one of the biggest sport events in Africa, will demand effective collaboration among all transport modes. U.S. \$ 11 billion has also been appropriated for transport infrastructure in preparation for the 2017 Soccer African Cup by the Libyan government, distributed to roads, rail, air and ground transportation system (National Department of Transport strategic plan for 2017 Soccer African Cup, 2010).

In Libya, cars, airlines, general aviation (privately owned aircraft), buses, vans/min buses and share taxis are the main modes of intercity transports. For travel distances over 250 km, the market shares of intercity bus mode are considerably low than the market shares of automobile and commercial airline modes. Since 1960's automobiles have taken over intercity transports in Libya; whereas, the air service ranks second, and booming as an important component, mainly in the routes, where the traffic is heavy enough to need frequent services. Bus services cover small proportion of total journeys, and are considered as an essential alternative to cars in low-density passages, serving countryside neighborhoods and smaller towns. Shared taxis are available for intercity travel as in other countries (National Department of Transport in Libya, 2010).

Travel demand administration continues to receive escalating focus, because of its prospective to address transport issues in many countries including, Libya. Managing travel demand includes planning for a suitable transport system, as well as dealing with the problems of traffic jams, vehicle accidents and ecological contamination from the

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raising use of automobiles. The local government continues to enhance intercity public transport with various approaches, as there was the need to improve intercity public transport system of the country, therefore, the time is right to demand a policy, which will improve intercity transport, and vehicle ownership regulations. The Libyan government has conducted several studies to overcome these problems [1]-[3]. In this situation, government policy encourages people to use other mode of intercity transportation instead of their private car for reduction of traffic accident, congestion and air pollution [4]-[7].

Planning is the initial step in any engineering project; especially it is very crucial in transportation, since transportation systems are amongst the most highly-priced ventures to develop or customize. The financial commitment in enhancements of transportation must be based upon the recognition of future demand. It is essential to understand the behavior of travelers, to accomplish the above, especially, for getting the most probable parameters to be included in the model.

Understanding the nature of intercity trips and the ability to estimate the choice of travel mode becomes important in the planning of intercity facilities, and particularly for organizations providing transport services. The main goal of this study is to develop a model for disaggregate (i.e. individual) travel mode choices among business travelers in Libya.

Mode choice is an essential and important step in transportation planning. This is because public transport plays a key role in policy decisions [8]. Results of intercity travel behavior analysis, based on mode choice can be used for demand forecasting and service pricing. Travel behavior research however, is far from complete in the intercity travel market, especially when compared with urban travel analysis. There is a need to understand travelers' preferences and willingness to choose among the existing or potential alternatives, such as, intercity bus services, automobiles, and airplanes.

Worldwide, numerous intercity mode choice models have been formulated and employed to forecast choice of travelers. In the context of planning, these modeling are fairly significant, since the transportation systems generally need massive financial commitment [9]. Around 1973, Watson [10] has developed the first disaggregate model for intercity mode choice, in which he has outlined two options (rail vs. automobile) making use of the information pertaining to individual travelers on the Edinburgh-Glasgow route (Scotland). He has determined that, the utilization of disaggregate, behavioral, stochastic models in a predictive structure, is more advantageous than the aggregate technique, simply because the predictions of disaggregate models are incredibly encouraging. Consequently, a lot of studies have focused on disaggregate mode choice in the context of intercity travel [11]-[23]. These studies have examined probabilistic models, which only target on making a particular choice, as soon as the traveler has determined to make a trip.

Studies progressed from a binary logit model, to a multinomial logit model, and to the nested logit model.

However, so far none of the studies have been conducted in Libya on the intercity mode choice behavior, therefore, this present research has focused on the development of a multinomial logit model for intercity business trips, using disaggregate mode choice data, and has incorporated more socioeconomic variables, characterizing intercity travelers, for the purpose of improving our knowledge of intercity travel behavior.

Furthermore, it is essential to definitely understand aspects, which influence intercity trips, for designing the model. These aspects that impact intercity trips are essential to policy makers, for determining decisions on needs of intercity travelers. Consequently, the primary objective of this research project is to determine the significant aspects, which impact intercity travel demand mode choice, and to build appropriate mode choice models, which enable the perseverance of the share of each mode for intercity business trips in Libya. One of the goals of travel behavior studies is to comprehend the components, which trigger travelers to act as they do [24]. Nevertheless, there is considerable lack of potential to estimate intercity passenger travel behavior [25]. Therefore, this current research involves a lot of socio-economic factors, which define intercity travelers, so as to improve our comprehension of intercity travel behavior. We strongly believe that, this research will maximize our conceptual and scientific understanding about the awareness and behavior of travelers, towards existing transportation services. The developed model will be beneficial in building a approach, which will contribute to appropriate ventures towards infrastructure, to fulfill the needs of travelers, and offer trusted estimations about mode choices, by determining the features of the intercity travelers. It will support in planning pursuits, based on the parameters that get travel behavior. The model might help city planners, to present satisfactory infrastructure and the system to fulfill the needs, and encourage other modal choices.

## II. MATERIALS AND METHODS

The disaggregate data for this study were obtained from the transportation survey conducted by the authors in 2010. A total of 1300 respondents were involved and the study was conducted over three months. About two-thirds of the data was used for model calibration and the remaining data was used for model validation. The survey was designed to satisfy the requirements for the development of an intercity mode choice behavior model and to examine the significant aspects, which impact the selection of intercity travel mode in Libya.

Majority of the intercity travelers in Libya are from various nations, and Arabic and English are the most typical languages among travelers. Therefore, we had designed the questionnaire in both, Arabic and English. Three sets of questionnaires were used for the three types of modes, namely, private cars, intercity buses and airplanes, used for business trips. Furthermore, airport terminals, intercity bus terminals and natural journey break points, such as service areas and petrol

bunks situated between cities, were used the locations for conducting survey. The interviews were conducted in safe areas, without obstructing traffic flow.

The study was conducted in all main metropolitan areas in Libya, due to the availability of the high car possession, and intercity public transport, and adequate representation of travelers. Specifically, the respondents for this study were randomly selected from Tripoli, Benghazi, Surt, Sabha, and Al-Kufrah, depending on a stratified sampling strategy to accomplish a associate sample, which displays demographic and socioeconomic information. The airports considered in this study were based on their availability. The cities selected are estimated to be great instances that represent Libya.

The questions were arranged based on relevance to the respondents' experiences and trips. This questionnaire comprises extensive range of parameters, which characterize the trip (such as, travel mode, purpose of trip, origin, desired destination, and length of stay at destination), the service features of the selected mode, and the identified features of other accessible but un-selected modes (travel time, and cost), the features of travelers (which includes, age, gender, monthly family income, profession, revenue, nationality, vehicle ownership, and level of education), and travel behavior. Details on the response of each transport mode user towards the situations of proposed policy variables (measures) of every single transport mode user have also been acquired. The questionnaires were written with the names of the three distinct modes under study, such as: private cars, intercity buses and airplanes.

The questions that address airplane and intercity bus travelers were included only in the preference survey (RP), and associated with demographic and socioeconomic features and mode characteristics. The participants were requested to record their recent travel, by responding to a set of questions. For car users, the questionnaire dealt with both, revealed preferences (RP) and stated preferences (SP). The survey information incorporated socioeconomic features and trip information of travelers, and perceptions on travel and policy options. To ensure the practicality of the questionnaire it was tested with actual respondents in a pilot study prior to formal data collection. We had designed the pilot survey, to validate the aspects included in the primary survey tool. A random sample of 100 observations from intercity drivers during the study period were collected and analyzed. The analysis revealed that, some questions could be omitted from the questionnaire because the participants had either not answered them or had answered them erroneously. Some questions were modified or rewritten. After the questionnaire was developed, the main survey was conducted to collect the required data. Respondents were arbitrarily picked based on a stratified sampling technique, to get a associate sample showing demographic and socioeconomic profiles.

The logit function is a significant part of discrete choice and logistic regression [26], [27] Logit models were used with SPSS Software Version 20 and R Statistical Software due to their capability to characterize complicated factors of travel decisions of individuals, by integrating essential demographic

and policy-sensitive informative parameters. These models will not presume linearity in the associations between the independent and dependent variables, and do not need the parameters to be typically allocated. The logistic regression predicts the possibility of the occurrence of a specific event, based on the independent variables.

The discrete choice model is a mathematical function that predicts an individual's choice based on utility or relative attractiveness [9]. Hence, the use of the multinomial logit model under discrete choice methods was an analytically convenient modeling method. The intercity mode choice for intercity business trips was modeled using the disaggregate travel demand approach with the multinomial logit model (MNL). The technique is explained in detail by [45]. Briefly, the multinomial logit model has the following form:

$$P_n(i) = \exp(V_{in}) / \sum_{j=1}^K \exp(V_{jn}) \quad (1)$$

where:

$P_n(i)$  = probability of individual  $n$  choosing mode  $i$ ,

$V_{jn}$  = Utility derived by individual  $n$  from mode  $j$ ,

$K$  = number of available modes of transportation.

The utility by an individual  $n$  from mode  $j$ ,  $V_{jn}$ , is derived as a linear function of the explanatory variables as follows:

$$V_{jn} = \beta_{0j} + \beta_{1j}x_{1n} + \beta_{2j}x_{2n} + \dots + \beta_{nj}x_{qn} \quad (2)$$

where:

$\beta_{0j}$  = Alternative Specific constant for mode  $j$

$\beta_{1j}, \beta_{2j}, \dots, \beta_{nj}$  Coefficients associated with explanatory variables

$X_{1n}, X_{2n}, \dots, X_{qn}$  Explanatory variables for individual  $n$

$q$  = number of explanatory variables included in model.

### III. MODEL SPECIFICATION

The designing of the mode choice model needs extensive evaluation of observed data and the efficiency of the whole model system. Distinct requirements for the models have been assessed to identify, which requirements most effectively augments the data for various trip purposes. In the current study, specific parameters are predicted to impact travelers' behavior, when they have different choice of transportation modes. Some of the parameters (such as, travel cost and travel time) are considered to be substantial in literature, while other variables are presented exclusively to deal with specific research problems. These requirements consist of the parameters such as ( $G$ ) gender, ( $N$ ) nationality, ( $EL$ ) educational level, ( $INC$ ) monthly income in Libyan dinar, ( $CA$ ) car availability, ( $FT$ ) family trip, ( $DIST$ ) distance of travel in kilometers, ( $ACIST$ ) access distance to airports and intercity bus station in kilometers, ( $EGDIST$ ) egress distance from airport/bus terminal to final destination, ( $TTC$ ) total travel cost, ( $IVTT$ ) in-vehicle travel time in hours, ( $OOVTT$ ) out-of-vehicle travel time in hours, ( $DOS$ ) is the duration of stay at destination, ( $PRIV$ ) is privacy, ( $CONV$ ) is

convenience, (COMF) is comfort, (RELIAB) is reliability, (SAFE) is safety, (WETHC) weather conditions.

The parameters reviewed for intercity mode choice in Libya, were assessed as follows: The monthly income (INC) variable was assessed in Libyan Dinar (LYD) and built on an ordinal scale from 1 to 6 (<LYD 300, LYD 301–400, LYD 401–500, LYD 501–600, LYD 601–700, and >701 (Note: 1 LYD = 0.79 USA Dollar), It has been hypothesized that, travelers with various ranges of income, comprehend travel cost diversely. The gender was categorized as 1 for male and 0 for female. The family trip (FT) variable was set equal to one if a traveler is accompanied by his family and zero otherwise. A duration of stay at destination (DOS) variable was measured on an ordinal scale from one to four (1 = one-3 days, 2 = 4-7 days, 3 = 7-30 days, and 4 = more than 30 days). Car availability (CA) was also a binary variable set equal to 1, if an air/bus user has a car available for use for his/her trip, and 0 in any other case. Total travel cost (TTC) = for bus and airplane is the sum of (line hole travel cost (LHTC) + access cost (ACESC) from airports terminals and intercity bus station to final destination) and for private car is the sum of (fuel cost + oil cost + parking fees in Libyan dinar). (OOVTT) out-of-vehicle travel time in hours for airplane and intercity bus station, which is the sum of (access time (ACEST) to airports and intercity bus station + waiting time (WAITT) at airports and intercity bus station + egress time (EGRST) from airports terminals and intercity bus station to final destination) and for private car is the time at rest areas and gasoline stations

The data required for defining, designing, and validating transferability, contain three categories, such as: (1) socioeconomic variables, (2) level of services or supply variables, and (3) trip data. A number of these parameters are qualitative, whilst others are quantitative. The parameters that ideally describe the behavior of driver cannot be established while designing the model, except the consequences of the other parameters were examined at the initial modeling stage. A few of the tested models have demonstrated inadequate statistical goodness-of-fit and/or counter intuitive signs, and have been therefore invalidated. For example, some models generated a very good fit, but had a counter-intuitive sign in the variable total travel time. Precisely, the fundamental rules used to move from one requirement to another are: (i) variables with trivial coefficients were removed; and (ii) variables that had the “inappropriate” signs were eliminated.

A multinomial logit model for all intercity trips has been designed for three options such as, private car, airplanes and intercity buses, to compare the application of these travel modes and determine the aspects, which might impact car users to shift from traveling by car, to choose airplanes or buses. In this model, the dependent variable was “1” for intercity bus travel, “2” for airplane and “0” for car use [26, 28]. After the variables with insignificant coefficients were dropped from the model, the remaining explanatory variables were gender, nationality, monthly income, and duration of stay at destination, purpose of travel, access distance to airport/bus

terminal, total travel cost, car availability, and privacy and convenience.

The coefficients were estimated by fitting the data to the model(s). The maximum likelihood estimation method was used. This method involves choosing values for the coefficients to maximize the likelihood (or probability) that the model will predict the same choices made by the observed individuals. The method generally yields highly accurate estimates.

After the calibration process was completed, the developed models were validated. The models were validated using the data other than those were used for model calibration. For the purpose of model validation, 350 observations have been used. As mentioned earlier, the collected survey data was divided into two parts. The first part was used for model calibration whereas the second part was used for model validation. The validity of models was evaluated by comparing similarities in the observed and predicted choices.

#### IV. RESULTS AND DISCUSSION

Several variables, based on the review of literature, were used in the calibration process. Quite a number of models that were analyzed have revealed inadequate statistical goodness-of-fit and/or had counter-intuitive signs; and therefore they all were invalidated. The Table I presents the most acceptable model for intercity business trips. Many more variables were tested during the calibration process, but due to space considerations these trials are not presented here. As stated previously, the basic idea behind the intercity mode choice model estimation was to identify factors influencing the people of Libya to drive, and the circumstances that may persuade them to use other modes of intercity transport (airplanes or intercity buses). The basic test of the estimates are indicated by their signs (+ or -) and the impact of the corresponding variables [9].

The summary of estimations using the multinomial logit model is presented in Table I. All the variables presented had significant parameter estimates and logical signs. The level of service variables, such as total travel cost (TTC) is generally expected to have negative coefficients. As (TTC) increase, the probability of selecting the modes will decrease. As expected, they had the negative sign. A number of studies have considered travel cost to have a considerable adverse impact on the choice of travel mode (i.e. travelers look for cheaper modes).

Over the last few years, a number of intercity and mode choice researches have revealed the significance of travel cost. Algarad [29] developed intercity mode choice using disaggregate transport mode choice models, he found the level of service variable total travel cost was high significant and had negative coefficients. Kumar et al., [30] have examined rural intercity bus services in India, to recognize views of users towards various features of service. The attributes examined comprised, in-vehicle travel time, progression, distress, and travel expenses. As anticipated, the travel expenses or ticket fare adversely impacted on traveler utility. The United States [22], [23] has designed a national intercity

travel demand model, and as predicted, they have identified that, as travel cost elevated for a particular mode, the choice of the traveler dropped for that specific mode. Reference [31] Developed various choice models based on the stated preference data for modeling the intercity mode choice behavior in India. They found that the income and total travel cost play an important role in the mode choice decision for the intercity transport. The travel cost variable is specified as generic in the model. This implies that an increase of travel cost has the same impact on modal utility for the two modes.

In this present research, the demographic variables such as, age, and gender have substantially contributed to explain the intercity mode choice behavior. The coefficients for gender were positive, which implied that females were more likely to use intercity buses or airplanes than drive, the odds ratio for females being just about eight folds for women in contrast to men. This difference is likely due to two reasons: firstly, women have less access to the family vehicle(s) than men, and, secondly, they perceive driving to be more dangerous than men. Therefore, even with access to a car, women may still prefer not to drive. Another study has investigated gender and travel behavior among two Arab communities [32]. The study has revealed that, demographic factors such as, gender, impact travel mode in a different way, for females and males. Therefore, successful policy mediation must contemplate these differences gender, to deal with the travel demands of Arab communities. Gender analysis should be integrated into all transport planning, prior to project execution. Most essentially, gender analysis, entices the conventional, neoclassical evaluation, which considers at families as black boxes, and represents that, domestic behavior displays the choices of all individuals, irrespective of the power structure and gender relationships within these families. In this context, gender analysis is component of a general re-orientation of transport planning, which begins with an evaluation of fundamental domestic mobility requirements.

In the model, the age was found to explain significantly the intercity mode choice behavior. The age had a statistically significant ( $P < 0.05$ ) contribution to the explanation of intercity mode choice behavior. The positive sign of the coefficient for airplane users implies that old people are more likely to use airplane than their private cars. For bus users, the negative sign of the coefficient implies that younger people are more likely to use intercity bus than drive private cars. This result confirms with European outcomes. For example, Mackett and Ahen [40] have also identified that, the youth drive much less, being more prepared to take public transport than the aged.

The estimated coefficients for monthly income (INC) for intercity bus mode were as expected negative, implying that increases in their absolute values will increase driving. Shifting car users to the intercity buses was only likely if the fare can be reduced. The income (INC) for airplane modes was unexpectedly positive which means that the income factor has less significance and not as much influence as it does with bus trips, indicated that individuals with high income are more likely to use airplane for their intercity travel. Similar findings

have been reported previously [22], [23], and [31]. References [22], [23] identified that, travelers getting higher income were less sensitive to travel fares.

Car availability (CA) is obviously a major factor affecting intercity mode choice. This variable was used to investigate whether the traveler has a complete set of mode choices or he is captive to other modes. In the intra-urban literature, car ownership, possession of a driver's license, and car availability are used and interpreted in almost identical ways. This procedure may be justifiable in the inter-urban context, but certainly not in the intercity context. In this research, investigate number of the availability of a car at the time is taken intercity trip to find its effect on intercity mode choice; because, the use of a car for intercity trips usually means that the car will be used for a long time period. Thus, the car will be unavailable for other household members during that time. Furthermore, car ownership does not mean that the car is in good condition and reliable for intercity trips. As expected that availability of car at the time is taken intercity trip negatively affects the choice of air and intercity bus modes. The coefficients of car availability (CA) in the model were significant, and the negative sign of the coefficients indicate that most of users of intercity buses or airplanes do not have car available at the time is taken intercity trip, if they have a car available it is not in good condition and reliable for intercity trips. Car availability is therefore a major factor that determines the choice of intercity transport mode. Resistance to switching was observed among respondents who have one vehicle available, while respondents who have two or more vehicles were less resistant to mode change [34], [21].

Traveler's nationality was introduced into the questionnaires to identify if a distinction in travel behavior for intercity mode choice prevails among Libyan and non-Libyan residents. The coefficient of this variable indicated a significant effect on the mode choice of the traveler for intercity trips. The coefficient of nationality (N) was positive, indicated that the probability of selecting intercity buses or airplanes was greater for non-Libyans than Libyans.

Perceptual variables were introduced during the calibration to investigate the effect of incorporating these variables on the mode choice behavior of the traveler. The perceptions of mode privacy and convenience significantly affected the mode choice of the traveler for intercity trips. The coefficients were negative, hence implying that an increase in their absolute values will increase driving. [35] mentioned that, variables such as comfort, protection, and excellence may affect mode choice, but observed that only a few studies have reviewed these aspects, because of data constraints and challenges of modeling. The preference rankings of alternatives and perception indicators (such as comfort, convenience and reliability, etc.) had been considered, and the preference index computed from the estimation using the multinomial logit model [22], [36]. The results have showed that most parameters had the correct signs and the goodness-of-fit measure of the model with the preference index was significantly better than that of the model without it. It was confirmed that preference rankings and perception indicators

had a large effect on travel choice behavior.

TABLE I  
THE MULTINOMIAL MODE CHOICE MODEL ESTIMATES FOR ALL INTERCITY TRIPS IN LIBYA

Mode of Transport	Independent Variable Code	B	Std. Error	Sig.	Exp(B)	95% C.I.	
						Lower	Upper
Intercity Bus	Intercept	20.464	4.615	0.000			
	G	2.112	0.934	0.024	8.267	1.325	51.568
	N	2.436	1.027	0.018	11.423	1.527	85.425
	Age	-0.900	0.485	0.043	0.407	0.157	1.052
	INC (LYD)	-0.583	0.242	0.016	0.558	0.347	0.897
	CA	-2.000	0.645	0.002	0.135	0.038	0.479
	DOS	-0.819	0.390	0.036	0.441	0.205	0.947
	POT	1.271	0.491	0.010	3.563	1.360	9.336
	EGDIST	0.634	0.307	0.039	1.885	1.032	3.441
	FT	-3.187	1.002	0.001	0.041	0.006	0.294
	TTC	-0.063	0.011	0.000	0.939	0.918	0.960
	PRIV	-0.878	0.329	0.008	0.416	0.218	0.793
CONV	-0.493	0.297	0.047	0.611	0.342	1.093	
Airplane	Intercept	19.149	4.406	0.000			
	G	1.958	0.860	0.023	7.088	1.313	38.264
	N	1.850	0.869	0.033	6.361	1.159	34.921
	Age	2.059	0.584	0.000	7.839	2.497	24.606
	INC (LYD)	1.423	0.331	0.000	4.151	2.170	7.942
	CA	-3.671	0.678	0.000	0.025	0.007	0.096
	DOS	-1.418	0.397	0.000	0.242	0.111	0.527
	POT	-1.530	0.481	0.001	0.217	0.084	0.556
	EGDIST	-0.383	0.230	0.046	0.682	0.435	1.070
	FT	-3.254	0.930	0.000	0.039	0.006	0.239
	TTC	-0.028	0.009	0.004	0.973	0.955	0.991
	PRIV	-1.070	0.241	0.000	0.343	0.214	0.550
CONV	-0.622	0.201	0.002	0.537	0.362	0.796	
Summary of Statistics							
Number of observations					950		
(-2) Initial LL					2078.059		
(-2) Final LL					107.855		
Cox & Snell's R <sup>2</sup>					0.875		
Nagelkerke value					0.985		
McFadden's value					0.948		
Explanation of Variables Included in the Selected Model							
G	= Gender	CA	= Car availability				
N	= Nationality	EGDIST	= Egress distance from airport/bus terminal to final destination				
Age	= Age	TTC	= Total travel cost in (LYD)				
INC	= Monthly income in (LYD)	PRIV	= Privacy				
DOS	= Duration of stay at destination	CONV	= Convenience				
POT	= Purpose of Travel						

Note: The car as the base case was set to zero.

#### Models

$$(P)_{bus} = 20.464 + 2.112 (G) + 2.436 (N) - 0.900 (Age) - 0.583 (HINC) - 2.000 (CA) - 0.819 (DOS) + 1.271 (POT) + 0.634 (EGDIST) - 3.187 (FT) - 0.063 (TTC) - 0.878 (PRIV) - 0.493 (CONV)$$

$$(P)_{air} = 19.149 + 1.958 (G) + 1.850 (N) + 2.059 (Age) + 1.423 (HINC) - 3.671 (CA) - 1.418 (DOS) - 1.530 (POT) - 0.383 (EGDIST) - 3.254 (FT) - 0.028 (TTC) - 1.070 (PRIV) - 0.622 (CONV)$$

The purpose of travel (POT) variable had statistically significant ( $p < 0.05$ ) contribution to explanation of intercity mode choice behaviour. For airplane, purpose of travel (POT) had as expected negative sign of the coefficients indicate that the travelers make trip work or business are more likely to use airplane for their intercity trips, while had positive sign of the coefficients indicate that travelers make social and recreational trips are more likely to use to use bus or car. The results from

the survey indicated that the majority of work and personal business trips were made by air mode; in contrast, social and recreational trips were carried out using private car and intercity bus.

The duration of stay at destination (DOS) variable is identified to be considerable and adversely impacts the choice of the intercity bus and airplane mode, i.e. as the period of stay in destination increases, the possibility of selecting the intercity bus airplane mode considerably diminishes. If the travelers planning to stay long at destination, prefer to use their cars because of the high taxi prices, the poor quality of service, and lack of public transportation in major Libyan cities.

The size of the family that travels (FT) variable has been used to identify any possible relationship among the members of the group that travel together. The size of the household and the age of the family members traveling between cities, generally indicate the precise cost of the journey. The number of family members traveling together (family trip) is

considerable in impacting the car users' mode-choice behavior. The probability of selecting the airplane and intercity bus decreases as the family size increases because the variable family trip coefficient had a negative sign. It has been hypothesized that, family travelers will select the private car mode, which means that, when family members plan to travel as a group, the possibility of selecting air or intercity bus is believed to be low. Family travelers are assumed to select the private car mode at least for two reasons: (i) superiority of the private car mode as against airplane and bus, in terms of travel privacy; (ii) for a family trip, travel party size will be most possibly larger than two, and as travel costs are generally paid by the head of the family, the use of much cheaper mode is expected. [29], [33] and [37] studies which conducted in Saudi Arabia, they found that the size of the family traveling together had statistically significant on intercity mode choice behavior. The size of the travel party is also an essential factor, which is generally overlooked in a number of mode-choice studies [44]. As the size of the travel party rises, the automobile gets more economical.

The literature review reveals that several intercity mode choice researches have not included accessibility or passage distance variables. Within intercity mode choice models, analysis of access variables is generally restrained to calculating coefficients of access time and access cost. Therefore, in this study, the access and egress distance were introduced during the calibration to investigate the effect of incorporating these variables on the intercity mode choice behavior of the traveler. In this research, the egress distance from the airports or intercity bus terminals had more onerous than access distance. Because the lack of the accessibility modes of airports and intercity bus terminals. Therefore, most of the passengers in the city of departure said they accessed to the airports or intercity bus terminals dropped by a relatives or friends. This research found that egress distance from airports or intercity bus terminal to final destination are effected intercity mode choice decisions. Thus, reduced distances or improve the accessibility (access and egress modes of transport) to airports or intercity bus terminal can reduce vehicle trips by encouraging a shift from driving to airplane or intercity bus. Beimborn [41] has designed a basic model to examine the level that local access or terminal locations, impact the choice of an intercity mode. He has reconciled his model to evaluate travel between Washington, DC and Philadelphia. It is noteworthy that, Beimborn has revealed that, accessibility to intercity line-haul termini has a considerable impact on modal choice behavior. Leake and Underwood [42] have proposed an intercity terminal access modal choice model. Spear [43] has suggested that, models should be adjusted with data on passenger knowledge of ground access modes. This would enable researchers to identify how better promotion could improve ridership. In the current study, egress distance from airports and intercity bus stations (EGDIST) variable, for airplane was as expectedly has negative coefficient implying that increases in an egress distance from airports will increase driving, while for bus abruptly has optimistic coefficient and that could be because

of car users not contemplating terminal access/egress distance as significant, could be due to riders eyeing on improving intercity bus service and reliability more than the bus terminal access/egress distance.

All variable coefficients estimated using the multinomial logit model for all intercity trips were found to be statistically significant at the 0.05 confidence level, with a good fit and a high R-squared value. The model had a  $R^2$  value of 0.875, indicating that the independent variables could explain 87.5% of the variation in the dependent variable. The classification matrices of predicted vs. observed outcomes were calculated, and the model was found to correctly classify 97.9% of the car users, 98.3% of bus users and 97.8% of the airplane users. The predictions were 98% accurate.

The chi-square value has been employed to evaluate the complete relevance of the logit model. It has been calculated as -2LL (Log Likelihood) for the null model with only constants used as the explanatory variables, without -2LL for the completely specified model (Table I). The coefficients of the model were considerable ( $P < 0.05$ ), and the null hypothesis was invalidated, understanding that, the independent variables created no distinction in forecasting the dependent variable. The -2LL gauges how better the model suits the data, and is also known as the deviance. It depends on the squared variations among the discovered and estimated possibilities. The -2LL statistic is also known as the "goodness-of-fit" test. A well-fitted model will present a huge observed relevance at the  $P < 0.05$ , and this was in fact the case in this research, which proved that, the model fit was superior.

## V. CONCLUSIONS

The fundamental goal of this research is to build a mode choice model, which would deliver beneficial information to the policy-makers and transport planners. The proposed model might be beneficial to the planners in the sense that, it is receptive to a number of parameters, and consequently, can be used to estimate the impact of changes in the several features or the particular policy changes of the demand for each of modes

An intercity model must be available to estimate the potential modal split. In general the intercity disaggregate mode-choice behavior model for deference purpose of intercity trips (work, social and recreational) using private cars, intercity buses and airplanes in Libya was successfully developed and validated. The requirements of model utility might support in further research to emphasis on which data is essentially required. The model indicated that gender, age, traveler nationality, monthly income, car availability, purpose of travel, duration of stay at destination, egress distance to airport/bus terminal, total travel cost and mode characteristics (privacy and convenience) have impacted the choices associated with intercity travel mode choices for intercity travels in Libya. All the estimated coefficients possessed the expected signs and were statistically significant at the 5% level.

The two R-Squared values indicated the model's strong explanatory power. The factors included in the model accounted for 98.5 % of the variation for the Negelkerke, while the Cox and Snell-t explained 87.5 % and 94.8 % of the McFadden's value. The overall accuracy of the model prediction was 81%. The currently developed model was superior to previously developed models. In contrast to past observations on the instability of logit coefficients under different specifications [38], all currently developed models were robust in terms of goodness-of-fit, and almost all variable coefficients were stable. The literature suggests that "values of 0.2 to 0.4 for  $R^2$  represent an excellent fit" [39]. In this study however the R-square values for all developed models were always higher than 0.7.

The reasons why the car is so popular in Libya is that it is a convenient and comfortable way to travel, and the travelers have privacy, feel secure and it saves time. Other reasons include the lack of urban public transportation and high prices of taxis at the major cities in Libya. Moreover, the poor quality of the local airline services and ground intercity public transportation that does not have fixed information schedules for trips or easy-to-remember departure times does not encourage travelers to use them. Intercity passengers were therefore more concerned with egress than access. Moreover both airports and intercity bus stations do not have accessibility services. Therefore, passengers were more concerned with egress than access when they consider modal choices, since passengers arriving at airports or bus stations were considerably exposed to fatigue.

In conclusion, the results of this research, the model is distinctive because, it is a primary endeavor at national choice model calibration for Libya, the utility maximization principle, which was actually developed in the West, is suitable as an analytical foundation for modeling intercity travel mode choice in Libyan high ways reviewed in the study. This research will be extremely useful for intercity travel demand analysis by the Libyan Airlines and the Ministry of Transportation and Communication. It will also assist government and public transportation organizations and private providers in making suitable choices and avoid under/over designing of required amenities and services.

The outcomes of this study can be applied to assess current public transportation, and predict future intercity transport need. Decision-makers can utilize the outcomes to enhance intercity transport service and entice more travelers.

The methodology and conclusions of this study can hypothetically and empirically enhance the intercity demand modeling in transportation planning in Libya. The model developed by this study can also be utilized by private carriers, to approximate the probable repercussions of specific policies and investment planning. Subsequently, the effect of policy changes can be replicated in mode choice models. Consequently, the probable reactions of travelers, both, in shifting the mode and stimulated need, are incorporated in the model. Therefore, this model enhances the precision of predicting advocacy of various intercity carriers (airlines and buses). This precision can be further replicated in their income

projection.

## VI. RECOMMENDATIONS

We have suggested prospective areas of researches: future studies can focus on other factors of intercity passenger need, such as, traffic generation, distribution and assignment. Some of these factors can be examined concurrently, using abstract mode models. Individuals are most probable to be influenced by their previous experiences in intercity travel. In future studies, an attempt should be made to include questions associated with previous journeys, and attempt to evaluate the impact of previous choices over the current ones. The generation of this information will support in building a more reliable model, which will give a beneficial planning tool to the decision makers, and they can employ it to prepare transportation infrastructure enhancements in Libya.

Furthermore, in the model proposed in this study, travelers are presumed to utilize just one mode within the study period. Nonetheless, it is feasible that, in various circumstances, numerous modes can be used; this type of traveler behavior requires to be examined.

Researches based on the above recommendations might hypothetically and analytically enhance future intercity travel modeling, and could offer further ideas to transport organizations. It might also enhance the decision-making process of government and private carriers.

Future studies based on this simple model, should include the effect of other modes on intercity demand, include other corridors among Libyan cities, and identify an extensive countrywide model.

This study had been conducted with minimal data and financial resources. For similar study in the future, it is suggested that, database with more comprehensive information about trips of other transportation modes (shared taxi and vans) can be considered.

This present work is presently being expanded in a number of ways. Specifically, new research is focused towards building enhanced features, to maximize the sensitivity of the model to a wide range of policy options. For example, the model could handle perspective parameter such as, protection from climatic conditions. It was found that, users did not think that protection from climatic conditions impact their intercity mode choice, because this present study was carried out in winter. Therefore, we suggest that, a similar study can be conducted in summer and include the protection from climatic conditions, because the temperatures in Libya are high during summer, which might reach up to 55 ° C.

It is normal that in the future, population and consequently the trips will increase; therefore, the process of transportation planning should seriously concentrate on guiding trips to public transportation. Furthermore, the existing transport system in Libya does not successfully fulfill the need for the transporting goods and people. The 2017 Soccer African Cup, one of the biggest sport events in Africa, will need efficient collaboration among all transport modes. This type of research can be neither achievable nor valuable, without the coordination of related authorities and decision-makers, in



contemplating the outcomes and suggestions of this research. Bus companies should investigate the prospect of offering express intercity bus service during optimum periods, to entice more passengers such as, students and employees, who would like to report to duty/school/colleges on time.

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