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Modelling Work Trip Mode Choice Behaviour in Ondo State Nigeria Using Online Instrument and Multinomial Logit Technique

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Abstract- Being able to predict the decision making behaviour of commuters while taking into consideration the attributes of different transport modes is an important step to achieving the goals of sustainable commuting which include: safe mobility, traffic efficiency and reduced environmental burden. This study investigated the significant factors influencing work trip mode choices in Ondo State Nigeria. An online survey instrument was designed and a questionnaire administered to the working class population in the state through alumni whatsapp platforms, professional bodies, trade unions and associations. A total of seven explanatory variables was extracted from the responses and multinomial logit regression model was calibrated to fit the data and chi-square test was used to measure goodness of fit. The multinomial logit model identified gender, age, car ownership, nature of job, road condition, route safety perception and distance between home and work as the significant factors influencing work trip mode choice in the state. Additionally, 36.7% of the respondents used personal cars to make work trip, 55% used public transport (either of cab, mini bus, tricycle or motorcycle), while 8.3% walked to work. The percentage of car ownership was found to be 45% among respondents. Fifty percent (50%) of the respondents worked within 5km to their homes with 15% using personal cars, 26.7% used public transport and 8.3% made work trips by walking. This presents a good opportunity for the promotion of active transport. The findings from this study will be useful to transportation planners, policy makers and engineers in designing techniques for transitioning to more sustainable modes of transportation in Nigeria.

Key words: Mode Choice, Public Transport, Sustainability, Multinomial Logit Model

1.0 Introduction

The challenges of urban migration, uncontrolled population increase and rapid development puts a lot of pressure on the transportation sector in developing countries. Car ownership in Nigeria is at a low level compared to developed countries and this presents good opportunity to improve on the sustainability of the nation's transport system which is heavily dependent on informal public sector. The major modes of public transport used in Nigeria and particularly Ondo State include: mini buses, cabs, tricycles and commercial motorcycles which are controlled by the informal sector. Several challenges are associated with these modes, for instance, the wide acceptance of motorcycle and tricycle as a means of public transportation is believed by many to have increased safety and security concerns (Katsina, 2012, Ipindola et. al. 2020). Transportation related security challenges in Nigeria include; bag snatching, armed robbery, bus stop robbery, car theft etc. Several cases of armed robbers, kidnappers, and bag snatchers using motorcycle to perpetuate their acts have been recorded especially in densely populated urban areas in Nigeria (Kolawole and Afolabi, 2017). As a result, cities have started banning the use of motorcycles as a public transport mode. Recently, Lagos state banned the use of motorcycles and tricycles in some local government development areas due to road safety and security concerns, which caused unplanned public transport mode shift. The Ondo state government has also restricted the use of motorcycles as mode of public transportation in selected arterial roads in Akure metropolis. This might be difficult to achieve in other parts of Ondo state due to poor infrastructures, inadequate access to public transport, weak enforcement, low car ownership and unorganized public transportation system.

Being able to predict the decision making behaviour of commuters while taking into consideration the attributes of different transport modes is an important step to achieving the goals of sustainable commuting which include: safe mobility, traffic efficiency and reduced environmental burden. So much has been documented by researchers as touching mode choice analysis. Mode choice of commuters is influenced by a whole lot of variables which include: social, economic, cultural, environmental, travel time, travel cost, waiting time, number and ease of transfers, comfort, residential location, neighborhood type and urban form (Srinivasan and Walker, 2009; Li and Zhao, 2015; Minal and Chalumuri, 2016; Zhan et. al., 2016). Appleyard and Ferrell (2017) conducted a study to investigate the influence of crimes and their location on the propensity for commuters to choose physically active and environmentally sustainable travel modes. Multinomial logit (MNL) modeling was used to estimate the likelihood of an individual choosing a specific rapid transit mode out of a set of five choices, namely walking, cycling, riding a bus, driving a car, or being driven and dropped off. It was found that high rates of crime discouraged the use of transit, walking, bicycling, and encouraged driving. Lu and Kawamura (2010) employed data mining approach to model work trip mode choice analysis in Chicago, Illinois area of the United States of America. Woldeamanuel (2016) investigated the effect of parents' views of the safety and traffic conditions of younger teens' (12–16 years old) mode choice in the USA using a binomial logit model. It was found that the significant variables that affect younger teens' mode choice are the distance to school, traffic congestion, and crime rate along school routes. For longer distances and more traffic congestion and crime rates, using passenger cars was more likely compared to public transit and walking/bicycling. The impact of gender on work trip mode choice of commuters in suburban Montreal, Canada has been investigated by (Patterson, et. al, 2005). They concluded that women and men should be modeled separately for work trip mode choice. They equally inferred that women are less likely to choose public transit than men; women are more likely to choose rideshare and that women are less time-sensitive in regard to commuting than men are. However, most of the documented studies in this field was conducted in developed countries with transportation systems quite different from what is obtainable in a developing context like Nigeria. For instance, most of the urban centres in Nigeria are not planned and they are characterized with poor infrastructure and informal public transport systems. It is important to investigate the mode choice behaviour of commuters in developing countries in a bid to understand the factors of influence and designing localized solutions to transition to sustainable modes.

Road safety and security concerns are a major threat to transitioning to active modes of public transportation in Nigeria especially among the vulnerable (Children) population (Ipindola, 2019). For instance, subscription to sustainable modes such as walking and cycling for educational trips have reduced due to road safety and security concerns. Though several studies have investigated the impact of road safety on mode choices (Nevelsteen et al., 2012), the impact of factors such as route safety perception, road condition and nature of job on work trip mode choice in a developing country have not been documented. In a bid to understand the relationship between route safety perceptions, road condition, nature of job and work trip mode choice, multinomial logit regression model was calibrated and fit to the data collected through online survey instrument and chi-square test was used to measure goodness of fit. In addition, this study also explored urban and rural work trip mode choices to understand the differences for better transportation planning. Towns with functional public transport systems such as: mini buses, cabs and tricycles other than motorcycles are considered as urban areas and otherwise considered as rural areas in this study. Other factors such as: demography, location of job and distance from home was considered for work trip mode choice modelling in this study.

2.0 Methodology

2.1 Study Area

Ondo State is located in the southwestern part of Nigeria with coordinates $7^0 10^1$N $5^0 05^1$E (Figure 1). It is bounded by Ekiti state to the North, Kogi state in the Northeast, Edo state to the East, Delta State to the Southeast, Ogun state to the Southwest and Osun state to the Northwest and Atlantic Ocean to the South (Wikipedia, 2020). The state covers a land area of 15,500km^2 and has a population of 3,460,877. Agriculture, civil service and small and medium scale enterprises are the main occupation of the people of

Ondo state. The major modes of commuting in the state include: mini buses, cabs, tricycles and commercial motorcycles.

Figure 1: A map of Ondo State Showing the Eighteen (18) Local Governments (Akinbolati et. al. (2016).

2.2 Method of Collecting Travel Behavior Data

The advent of social media and internet of things (IoT) has made surveying easier and more sustainable, as there are no travelling and paper printing involved in online surveys. The data required for modelling distance based work trip mode choice was collected through web based online surveys (Survey Monkey) of working population in Ondo State. The research instrument used was a set of questionnaire comprising ten variables which are found significant in previous studies and they include demography, mode choice, distance between home and work, nature of job, location of home and work, car ownership and perception of safety and condition of road. The questionnaire was designed using Survey Monkey (an online based instrument for administering questionnaire) and a link to the designed questionnaire was shared on various alumni Whatsapp groups, professional bodies, trade unions and associations and other social media platforms. A total of 754 people responded to the survey out of which 668 were completed and considered valid. The number of completed survey meets the requirements and recommended sample size of not less than 500 in factor analysis studies (MacCallum et al., 1999).

2.3 Model Variables

The variables considered to be influencing work trip mode choice in Nigeria and their description were carefully selected after thorough literature review, interview with experts and stakeholders and personal observations as presented in Table 1. Public transport comprised mini buses, cabs, tricycles and commercial motorcycles.

Table 1: Work Trip Mode Choice Model Variables

VARIABLE	DESCRIPTION
MODE	0 – private car, 1 – public transport, 2 – walking
GENDER	0 if trip maker is a male, 1 if trip maker is a female
AGE Age 1 Age 2 Age 3	 0 if trip maker's age is between 17 and 40, 1 if otherwise 0 if trip maker's age is between 41 and 60, 1 if otherwise 0 if trip maker's age is 60 and above, 1 if otherwise
NATURE OF WORK	

Work 1 Work 2 Work 3	0 if trip maker is a public civil servant, 1 if otherwise 0 if trip maker is a private company or business employee, 1 if otherwise 0 if trip maker is self-employed, 1 if otherwise
DISTANCE Distance 1 Distance 2 Distance 3 Distance 4 Distance 5	 0 if distance from home to work is between 0 and 5 km, 1 if otherwise 0 if distance from home to work is between 6 and 10 km, 1 if otherwise 0 if distance from home to work is between 11 and 20 km, 1 if otherwise 0 if distance from home to work is between 21 and 30 km, 1 if otherwise 0 if distance from home to work is between 31 and above, 1 if otherwise
ROAD CONDITION Road 1 Road 2 Road 3 Road 4	 0 if road condition is very good, 1 if otherwise 0 if road condition if fairly good, 1 if otherwise 0 if road condition is poor, 1 if otherwise 0 if road condition is very poor, 1 if otherwise
ROUTE SAFETY Route 1 Route 2 Route 3 Route 4	 0 if route is perceived to be very safe by trip maker, 1 if otherwise 0 if route is perceived to be fairly safe by trip maker, 1 if otherwise 0 if trip maker's perception is indifferent, 1 if otherwise 0 if route is perceived not to be safe by trip maker, 1 if otherwise
PRIVATE MOBILITY	0 if trip maker owns a private car, 1 if otherwise
LOCATION OF WORK	0 if trip maker's work is located in an urban area, 1 if located in rural area
LOCATION OF HOME	0 if trip maker's home is located in an urban area, 1 if located in a rural area

2.4 Model Development

Multinomial Logistic Regression model was employed to establish a relationship between work trip mode choice and explanatory variables in a bid to identify the significant factors of influence. The explanatory variables selected for model calibration, their description and codes are presented in Table 1. The mathematical expressions proposed by (Hosmer and Lemeshow, 2000) was employed in calibrated the MNL model as presented in Equations 1 and 2. 'Y' is considered as the dependent variable which is work trip mode choice, while X1, X2…Xn are the explanatory variables. 'Y' consist three choices namely: private car, public transport and walking. Two logit functions – logit1 and logit2 are generated and expressed below:

$$\text{logit}_1 = \ln\left[\frac{p(Y=\frac{1}{X})}{p(Y=\frac{0}{X})}\right] = \beta_{10} + \beta_{11}X_1 + \beta_{12}X_2 + \cdots + \beta_{1n}X_n \quad (1)$$

$$\text{logit}_2 = \ln\left[\frac{p(Y=\frac{2}{X})}{p(Y=\frac{0}{X})}\right] = \beta_{20} + \beta_{21}X_1 + \beta_{22}X_2 + \cdots + \beta_{2n}X_n \quad (2)$$

Where:

Logit1 represents a logit function for private car versus walking, while logit2 represents a logit function for public transport versus walking. Walking is the reference group in this model.

$\boldsymbol{\beta}_{10}$ and $\boldsymbol{\beta}_{20}$ represent the intercepts and $\boldsymbol{\beta}_{11}$, $\boldsymbol{\beta}_{21}$, etc. represent the coefficients of the explanatory variables.

The odds ratio is the exponent of the coefficient obtained for characteristics in the logit model. When odds ratio is < 1, there is a higher chance of workers making work trip walking. If the odds ratio is > 1, it implies that an increase in the level of explanatory variables lead to a higher chance of making work trip using private car for logit_1 and public transport for logit_2. The significance of the MNL model is tested using *likelihood ratio*. The model estimation was implemented using SPSS statistical package.

3.0 Results and Discussion

The summary of the characteristics of the explanatory variable in relation to work trip mode choices is presented as follows:

3.1 Mode Choice versus Age

Majority of the respondents (75%) fall into the age category one (17 – 40 years), while 23.3% fall in the age category two (41 – 60 years) and 1.7% fall in category three (61 and above). Thirty six percent (36.7%) of the respondents made work trip using personal car with 19% falling in the age group (17 – 40), 16.7% falling in the age group (41 – 60) and 1% falling in the age group (60 and above). fifty five percent (55%) made work trip using public transport (either cab, bus, tricycle or motorcycle). Of this percentage, 46.7% fall within the age group (17 – 40), 8.3% fall within the age group (41 – 60), no one within the age group (60 and above) made work trips using public transport. A total of 8.3% of the respondents made work trip by walking and they all fall in the age category (17 – 40). This results is in tandem with (Woldeamanuel, 2016) that claims that younger people tend to use public transport more than their older counterparts.

3.2 Mode Choice versus Gender

Sixty seven percent (67%) of the respondents were males while 33% were females. Among the male population, 32% made work trips in private cars, 31.7% used public transport, while 3.3% walked to work. Among the female population, 5% made work trips using private cars, 23% used public transport, while 5% walked to work. While the percentage of private car and public transport seems to be balanced for males, majority of the female workers tend to use public transport. Patterson, et. al, (2005) suggested that mode choice be modelled separately for males and females because of differing factors of influence. This disparity is perceived to be influenced by cultural beliefs.

3.3 Mode Choice versus Distance

Fifty percent (50%) of the respondents reported that the distance between their home and work is within the range 0 – 5km out of which 15% made work trip using private car, 26.7% used public transport and 8.3% walked. Twenty one percent (21.7%) reported work distance of 6 - 10km with 15% making work trip using private car and 6.7% using public transport. Eight percent (8%) reported a work distance ranging between 11km and 20km, 11.7% reported a work distance range between 21km and 30km, while 8% reported a distance above 30km. The trend observed here is that, as distance to work increases the use of private car and walking decreases while the use of public transport increases. The potential for active transport promotion is huge considering the proximity of job locations to homes. Future research can model various distance ranges separately to better understand its impact on work trip mode choice.

3.4 Mode Choice versus Car Ownership

Forty five percent (45%) of the respondents own cars while 55% do not own cars. Of the 45% that own cars, 31.7% made work trips using their personal cars, 11.7% used public transport, while 1.6% walked to work. Out of the 55% that do not own cars, 5% made work trips in private cars, 43.3% used public transport, while 6.7% walked to work. Car ownership obviously impacts mode choice as highlighted by the findings of (Srinivasan and Walker, 2009). Achieving reduction in car ownership thereby promoting sustainable transport modes will be a difficult task in Nigeria where car ownership is seen as an object of social status and the public transport sector is not formalized.

Mode Choice versus Road Condition

Ten percent of respondents (10%) reported the road to work to be very good, 66.7% reported it to be fairly good, 18.3% poor and 5% very poor. Out of the percentage that reported the road to work to be good, 5% made work trip using private cars, 3.3% use public transport, while 1.7% walk to work. Out of the 66.7% that reported the road to be fairly good, 25% made work trip using private car, 36.7% used public transport, while 5% walked to work. Good road conditions has a way of encouraging private car use in Nigeria. Where the road surface conditions are not good commuters prefer to use public transport because of maintenance cost on personal cars. The government will have to put measures in place to encourage public transport use as the roads are being repaired.

3.5 Mode Choice versus Nature of Job

Forty three percent (43.3%) of the respondents are government workers out of which 25% made work trips in private cars, 18.3% used public transport and no percentage walked to work. 41.7% were private company workers with only 3.3% making work trips using private car, 31.7% used public transport and 6.7% walked to work. 15% were self-employed with 8.3% making work trips using private car, 5% used public transport and 1.7% walked. This statistics reveal that private company workers use public transport and walk more than government workers. This may be due to socioeconomic factor. Government workers have more secured and well-paying jobs than their private counterpart thereby increasing car ownership. Modelling these two categories separately could provide more insight into mode choice behaviour.

3.6 Mode Choice versus Job Location

Sixty eight percent (68.3%) of respondents reported to work in urban centres, with 26.7% making work trips in private cars, 36.7% used public transport and 5% walked. 31.7% reported to work in rural areas with 10% making work trips using private cars, 18.3% used public transport and 3.3% walked. 65% of the respondents live and work in urban centres, 3.3% work in urban centres but live in rural areas, 5% work in rural areas but live in urban centres, while 26.7% live and work in rural areas. The rural areas have the challenge of poor access to public transport which encourages the use of private cars. A large percentage of the rural areas in Ondo state have motorcycle as the only means of public transport which some perceive to be unsafe for commuting (Ipindola et. al. 2020).

3.7 Mode Choice versus Route Safety

Thirty eight 38.3% of respondents perceived the route to work to be very safe with 13.3% using private car, 20% used public transport and 5% walked. 45% perceived the route to work to be fairly safe with 18.3% using private car, 25% used public transport and 1.7% walked. This result is in tandem with the findings of (Appleyard and Ferrell, 2017). Commuters are discouraged from using active transport and public transport modes when they perceive routes to be unsafe.

3.8 Multinomial Logit Model Results

Pearson correlation was conducted on the explanatory variables of distance-based work trip. Home and work locations were found to highly correlate at 0.01 level of significance (2 tailed). Hence, home location was excluded from the model development. The location of work was retained because of its perceived importance in transitioning into more sustainable work trip mode choices.

Log likelihood ratio test was conducted on the selected variables for model development and the variables found to significantly influence work trip mode choice at 95% confidence interval include: gender, age, car ownership, nature of work, work location, route safety, road condition, and distance between home and work. These eight variables were used to develop the final mode choice model and the model fitting information presented in Table 2. The difference observed in the -2log likelihood values associated with the "intercept only" and "final" model reveals that the "final" improved upon the "intercept only" model. The log-likelihood of -33.14 for the final model is significant at 0.05 level of significance. This indicates that the model provides a good fit to the data. The chi-square statistics for the calibrated model is 70.34 which reject the hypothesis that all the predictor coefficient are equal to zero.

Table 2: Model Fitting Information

Model	Log-likelihood	Chi-square	p-value
Intercept only	203.482		
Final	133.141	70.340	< 0.0001

In order to identify the significant factors influencing distance-based work trips multinomial logit model was calibrated. Table 3 presents the results of the coefficients of explanatory variables, standard error, significance and odds ratio as computed by two logit models. Walking is treated as the reference group in relation to private car in logit1. The intercept of logit1 gives a positive value of 8.98. This infers that zero

estimates for predictor variables increases the chances of making work trips using private cars by 8.98. Car ownership has an estimate of 1.91 which indicates that a unit increase in car ownership increases the chances of making work trips using private car provided all other variables are held constant. A unit increase in age bracket (17 – 40 years) increases the chances of making work trips using private vehicle by 5.9, while a unit increases in the age bracket (41 – 60) reduces the chances of making work trips using private vehicle by -9.4 provided all other variables are held constant. All other model parameter estimates are negative signifying that, a unit decrease in these variables increase the chances of workers using private vehicles for making work related trips provided all other variables are held constant. A unit increase in the distance between work and home increases the chances of making work trips using public transport. This may be due in part to cost of buying fuel for personal cars.

In the case of logit2 walking is treated as the reference group in relation to public transport. The intercept has a positive value of 5.096 which indicates the likelihood of workers making work trips using public transport provided all the explanatory variable estimates are zero. Car ownership has an estimate of 1.227 which indicates that a unit increase in this variable increases the chances of workers making work trips using public transport. A unit increase in age brackets (17 – 40 years and 41 – 60years) increase the chances of workers making work trips using public transport provided all other variables are held constant. Predictor variables: gender, nature of work, road condition, route safety and distance all have negative estimates which indicates that a unit increase in these parameters increases the chances of walking to work. A unit increase in the distance between work and home reduced the chances of walking to work provided that all other variables are held constant. The variables: age group 60 and above, very poor road condition, and distance 31km and above are set to zero in the final models because they are redundant.

Table 3: Parameter Estimates of Mode Choice Model

Model	Variable	Coeff	SE	Sig.	Odds Ratio
Logit 1	Intercept	8.980	1.472	0.005	
	Gender	-0.337	0.692	0.001	1.245
	Car ownership	1.91	1.108	0.032	2.173
	Age 1	5.91	0.742	0.572	1.061
	Age 2	-9.4	0.432	0.004	0.965
	Age 3	0			
	Work 1	-0.765	0.765	0.007	2.437
	Work 2	-0.961	1.042	0.119	0.481
	Work 3	2.484	0.232	0.008	1.364
	Road 1	-1.310	1.053	0.220	0.144
	Road 2	-0.272	0.540	0.601	2.855
	Road 3	-9.592	1.432	0.005	0.221
	Road 4	0			
	Safety 1	-1.066	0.742	0.412	0.297
	Safety 2	-0.996	0.722	0.002	0.445
	Safety 3	-3.810	0.341	0.387	1.599
	Distance 1	-1.484	0.651	0.1	0.854
	Distance 2	-0.327	1.223	0.012	0.211
	Distance 3	-0.626	0.392	0.267	0.723
	Distance 4	-5.071	0.738	0.004	1.255
	Distance 5	0			
Logit 2	Intercept	5.096	0.803	0.006	
	Gender	-8.722	0.446	0.008	0.543
	Car ownership	1.227	1.308	0.322	1.765
	Age 1	2.421	0.366	0.010	3.211
	Age 2	0.805	0.489	0.79	2.870

	Age 3	0			
	Work 1	-2.793	0.843	0.032	0.213
	Work 2	-0.369	1.653	0.008	0.622
	Work 3	-0.999	1.322	0.533	1.633
	Road 1	-2.793	0.799	0.006	0.776
	Road 2	-0.369	0.522	0.204	0.421
	Road 3	-0.999	0.337	0.622	0.552
	Road 4	0			
	Safety 1	-3.934	0.932	0.006	0.380
	Safety 2	-1.963	0.650	0.135	0.172
	Safety 3	-0.306	1.722	0.459	0.648
	Distance 1	-1.696	0.721	0.087	0.563
	Distance 2	-0.840	0.389	0.007	0.243
	Distance 3	-3.862	1.225	0.012	0.742
	Distance 4	-0.417	0.344	0.018	0.145
	Distance 5	0			

4.0 Conclusion and Recommendation

The relationship between mode choice behavior of workers and the significant factors of influence has been explored in this study using multinomial logit regression model. The model successfully identified gender, age, car ownership, nature of job, route safety perception, road condition and distance of work from home as significant factors influencing work trip mode choice.

In order to achieve a successful shift to more sustainable mode choices, it is important for government at all levels to provide good infrastructure and enabling environment backed by technically informed policy. More so, education, advocacy and campaigns sensitizing the population on the impact of their mode choice behaviour on the environment should be explored and promoted.

The scope of this study was limited to workers with internet enabled devices who could respond to our online survey. Non smart phone users might have a different mode choice behavior, hence the need for future research to device a technique of incorporating workers especially in the rural areas with weak internet infrastructure. More so, future research can focus on specific routes for in depth study of the impact of road condition, safety and distance on mode choice behavior.

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