

Discrete choice models and individual travel constraints in Nigeria: A literature review

By

Suleiman G. Purokayo⁰
School of Economics, Finance and Banking
Universiti Utara, Sintok, Kedah 06010, Malaysia.

Hussin Abdallah¹
School of Economics, Finance and Banking,
Universiti Utara Malaysia, Sintok, Kedah, Malaysia.

Jan Jan, Soon²
Economics Undergraduate Programme Coordinator
School of Economics, Finance & Banking
Universiti Utara, Sintok, Kedah, Malaysia

Abstract

The main concern of this study is to highlight the many sided travel constraints and its effects on the travel decisions of individuals, especially small traders and other groups that daily need to make such decisions; it effects on cost of doing business in Nigeria. The paper is a survey of literature and on the ground assessment of contemporary Nigeria transport sector. Discrete choice models have been applied to travel decisions, which is the main part of derived demand and its probability applications. The study recommends public action in two areas: Growing insecurity in the country generally, specifically on some Northern Nigerian roads and border routes, and secondly the need for growth in the public-private-partnership (PPP) in road building and maintenance of existing roads.

Keywords: Discrete choice models, travel behaviour, travel constraints, road infrastructure.

⁰, PhD student, ^{1,2} Senior Lecturer.

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40 1. Introduction

41 Modelling travel decisions is an integral part of demand analysis. There are various methods/models of
 42 measuring consumer behaviour in different economic and non-economic activities. Modelling process involves
 43 disaggregation of individual travel behaviour overtime for instance. It is important to measure individuals or
 44 household, because the choice or decision is individualistic - all aimed at utility maximization, and analysis
 45 done towards observing individual consumer behaviour. According to Ben-Akiva, (1999), models that involve
 46 discrete choice are also referred to as disaggregate models, meaning that the decision-maker is assumed to be an
 47 individual. The importance of this is to be able discover what are the criteria of individuals in choosing from
 48 alternatives or from the choice set.

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50 Other models of discrete choice have examined features of the consumer in the process of making choices. For
 51 instance, Luce, (2008) models with probabilistic decision rules, that in the probability distribution, the
 52 assignment of a probability $P(x)$ to each outcome x are equally likely to occur. This supports heterogeneity of
 53 human behaviour which suggests that the decision rule should include a probabilistic dimension due to the
 54 prevalence of uncertainty elements. Some of the models – the deterministic model for instance, suggest that an
 55 individual has perfect knowledge of choices. (Werndl, 2011) opined that a model is deterministic iff, any two
 56 solutions that agree at one time agree at all times. However, due to mutually exclusive nature of events or
 57 choices, such events or choices cannot occur at the same time, for instance the choice of a transport mode
 58 between a car and a bus, or choosing to reach a destination, an individual must decide on the ‘right’ route to the
 59 destination, shows that all elements in the choice set are important. Thus in probability theory, events $E_1, E_2,$
 60 $\dots, E_n$ are said to be mutually exclusive if the occurrence of any one of them automatically implies the non-
 61 occurrence of the remaining.

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63 The discrete choice model (DCM) had been used as a tool of analysis and prediction of travel decisions.
 64 Discrete choice model predicts a decision made by an individual (such as mode or route choice) as a function of
 65 any number of variables. (Pavlyuk & Gromule, 2010). The framework for a discrete choice model can be
 66 presented by a set of general assumptions. In a typical discrete choice model, assumptions about the individual
 67 making the decision given an array of alternatives or options available is made, the attributes defining benefits
 68 and cost is made, and actions taken by the decision maker which are referred to as the decision rule – the

process used in choosing an alternative is brought into focus. These assumptions are vital in defining the environment of choice and constraints of an individual utility maximization. Utility theories are based on the assumption that individuals maximize their utility. This means that the individual gives each destination a utility value, and that the likelihood of an individual choosing a particular destination depends on the utility of that choice compared to the utility of all choices. In microeconomics, utility maximization is where the marginal utility per Naira (N) spent is the same for each of the goods.

$$-\frac{MU_x}{MU_y} = -\frac{P_x}{P_y} \Rightarrow \frac{MU_x}{P_x} = \frac{MU_y}{P_y}$$

Given various transport types (modes), an individual or corporate individuals will maximize their utility where $\frac{MU_{m1}}{P_{m1}} = \frac{MU_{m2}}{P_{m2}}$, Where $m1$ = transport through trunk A road and $m2$ = trunk B road, and MU is marginal Utility, while P is the transport price.

Nigeria has significant infrastructure challenges. Challenges range from the growing gaps in fiscal deficits. There are endemic budget deficits and lack of efficient management of large infrastructures by the public sector finances, good political ‘conscience’ to undertake efficient infrastructures projects (in terms of the engineering work), and most literature have strong standing that Nigerian roads are not properly built (A. Campbell, 2009; D. Campbell, 2012; Okojie, 2012). The poor state of road infrastructure has had implications in the cost of operating vehicles. According to FERMA², car owners spend N219,500 (about \$1,464) for every 10,000 kilometers of road used. The implication of this is the resulting high cost of transactions in Nigeria. The state of roads have resulted in travel constraints in terms of travel time, cost, travel mode choice, and especially that the Northern Nigeria depends on import of goods from major ports in the southern part of Nigeria. Accessibility in most Nigerian roads, including large rural populace that supply 60 percent of agro-allied goods suffer most in need of accessibility to reach desired economic activities which affects their socioeconomic life. A measure that is often used is determining accessibility in a transportation analysis zone is:

$$Accessibility_i = \sum_j Opportunities_j \times f(C_{ij})$$

Where:

i = index of origin zones

j = index of destination zones

$f(C_{ij})$ = function of generalized travel cost (so that nearer or less expensive places are weighted more than farther or more expensive places).

² Federal Road Maintenance Agency (FERMA), a government agency

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99 Although accessibility-enhancing strategies expand the range of choice for individuals and increase the
 100 possibility of connectivity, they do not ensure that individuals will actually choose some modes or a roads
 101 network due to several travel needs and costs (Hashim & Meagher, 1999). Accessibility have many components
 102 - connection, movement, cost, time, and comfort. Mobility is sometimes defined to have same meaning with
 103 accessibility. Mobility according to Picket et al, (2000) is the quality or state of being mobile and “mobile” as
 104 “capable of moving or of being moved readily from place to place”. This is important because it guides an
 105 individual into making a choice. The probability P_{ij} of individual i choosing product j from a set of products,
 106 given U is utility is

$$P_{ij} = Pr[u_{ij} > \{u_{ij'}\}_{\forall j' \neq j}] \quad \text{Could also be shown as } P_i = P(U_i > V_n) \text{ for all } j \neq n$$

$$= Pr[v_{ij} + \varepsilon_{ij} > \{v_{ij'} + \varepsilon_{ij'}\}_{\forall j' \neq j}]$$

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 111 Where V_i is the short form for $V(X_j, S; \beta)$. The response probability depends not only on the utility differences
 112 $V_i - V_n$, but also on the random utility difference portrayed by other decisions not observed across the population
 113 $(\varepsilon_n - \varepsilon_i)$. Take for instance that our product is a transport mode (deciding a type of transport) or types of vehicles
 114 available, while the probability of choosing a car is: $P\{\text{car, bus, and bicycle}\}(\text{car}) = P\{\text{car, bus, bicycle}\}(\{\text{car,}$
 115 $\text{bus}\}) P\{\text{car, bus}\}(\text{car})^1$ going from various types of vehicles to finally a car. This is the lace model. The model
 116 is important in dealing with uncertainty. Instead of identifying one alternative as the chosen option, it assigns to
 117 each option an alternative, a probability to be chosen (Bierlaire, 1997)

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119 The objective of this study is to highlight the many sided travel constraints and its effects on the travel decision
 120 of individuals, especially small traders and other groups that daily needs to make travel decisions – how it
 121 affects cost of doing business in Nigeria.

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123 The rest of this paper is structured as follows: Section 2 is the survey of literature on some travel-based models,
 124 Section 3, selected policies, public programmes, and effects on Road transport, Section 4, review of
 125 transportation policy and constraints and Section 5, is conclusion and recommendations.

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130 2. Literature Review

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132 2.1 Random Utility Models

133 Random Utility model (RUM) is based on observed and unobserved utility of individuals. The observed
134 characteristics and a stochastic error is taken into consideration, such that the researcher determines the mean
135 utility and random term. Thus $U(x) = v(x) + e(x)$.

136 The probability of individual i choosing product j from a set of products/services is:

$$\begin{aligned} 137 \quad P_{ij} &= Pr[u_{ij} > \{u_{ij'}\}_{\forall j' \neq j}] \\ 138 \quad &= Pr[v_{ij} + \varepsilon_{ij} > \{v_{ij'} + \varepsilon_{ij'}\}_{\forall j' \neq j}] \end{aligned}$$

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140 Where V_i is the short form for $V(X_j, S; \beta)$. The response probability depends not only on the utility differences
141 $V_i - V_n$, but also on the random utility difference portrayed by other decisions not observed across the population
142 $(\varepsilon_n - \varepsilon_1)$. Random utility models take its roots from the rationality of the consumer, as in economic consumer
143 theory, that the decision maker has a perfect discrimination capacity, choosing the best from a set of
144 alternatives. (Manski & Lerman, 1977), identified four different sources of uncertainty: unobserved alternative
145 attributers; unobserved individual characteristics (also known as “unobserved taste variation” in Handbook of
146 transportation science)²; measurement errors; and proxy, or instrumental variables. Utility is modelled as a
147 random variable in order to reflect uncertainty element. In most cases, travel choices are made among finite
148 number of discrete alternatives that exhibit choices than are probabilistic. Examples of such are models
149 proposed by Luce, (2008), and belong to the family of models with probability decision rules.

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151 In probability theory, Luce's choice axiom states that the probability of selecting one item over another from a
152 pool of many items is not affected by the presence or absence of other items in the pool. Selection of this kind is
153 said to have independence from irrelevant alternatives (IIA) - whether A or B is better should not be changed by
154 the availability of X, which is irrelevant to the choice between A and B. In a typical developing country, the
155 working of ‘irrelevant alternative’ can be looked upon as the so called ‘lesser evil choice.’ Where an individual
156 is constraint to make a choice that endangers their health. Consider a choice where the individual has perfect
157 knowledge of a route that could endanger them – the choice of migrants to Europe on high seas, where most
158 travellers are in danger of death, with few escapes. The decision maker is aware of the dangers from media or
159 life stories. Thus IIA is contentious, it is controversial for two reasons: first, some theorists find it too strict an

axiom; second, experiments and others have shown that human behaviour rarely adheres to this axiom, and thus the working of is strict of human.(Kahneman & Tversky, 1996). The “elimination by aspects” approach proposed by (Tversky & Kahneman, 1973), on the other hand, supposes that decision makers follow a particular heuristic (experience-based techniques) during a process of sequential choice. Options are described by their attributes and, at each decision stage, the individuals eliminate all the options not having an expected given attribute, and so until only one option remains.

In an ideal situation the availability of an array of options exists, an individual may make such choice, except the choices is binary in nature, travel (1) and not travel (0), thus choice is (0). In landlocked areas of Africa, preventable occurrences of deaths, complication in a pregnancy cases, the decision (0) means death. In Rural Nigeria, the prevalence of deaths as a result transport accessibility abounds in Nigeria (Iliyasu, Abubakar, Galadanci, & Aliyu, 2010; Kawuwa, Mairiga, & Usman, 2007; Ouro-Bang'na, Kabore, Zoumenou, Gnassingbe, & Chobli, 2008; Tukur et al., 2010), These studies argue that maternal mortality can be prevented if women access health facilities, but in most cases deaths occur for women and children who live 10 – 15 kilometers from the nearest maternities or health centres. Modelling this:

$$y_i = x_i \beta_i + \varepsilon_i$$

Where, x_i =vector of values, β = vector of parameters and ε is the error term. $Y=1$ available mode of transport (car or bus) and (0) no available mode (even when animals (horse or donkey) are used in transport, the travel time is affected and the comfort of the pregnant women in jeopardy).

The conditional expectation of y given $x = E(y|x) = \alpha + \beta x_i + \varepsilon_i$

Individual travel decisions in some parts of Nigeria are constraint by various aspects ranging from public finance issues that dictate connectivity (new roads and maintenance of existing roads), accessibility and travel time. In some cases difficult terrains exist in most of Nigeria. In the northern parts, the terrain range from desert conditions that affects the life span of roads (although there other conditions – corruption which affects quality of roads). There also other terrains related wetlands typography in the middle belt states of Nigeria exist. In the Southern parts, landlocked areas, high erosion, little accessibility due lack of new roads exist. Let us summarise these constraints:

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191 Travel time (TT), Risks on the roads (Ri), landlocked (LL), low investment in new roads (Li),
192 availability of type of transport (Mo), alternative transport (At), etc We build a hypothetical model:

193 The dependant variable – *Cost of travel* (CoT), $CoT = 1$ if available means exist and cost, and (0) if
194 otherwise. $CoT = \beta_0 + \beta_1 TT + \beta_2 Ri + \beta_3 LL + \beta_4 Li + \beta_5 Mo + \beta_6 At + E$

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196 This hypothetical model is to help us determine the cost of transport given various factors available. The
197 evaluation of cost and risks excludes most Nigerians from travel - including business trips.

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199 **3. Selected policies, public programmes, and effects on Road transport**

200 *3.1 Public Investment*

201 Better roads provide the only scope for better access to markets, education, health care and social development
202 for majority of African (IRF, 2008). This is also the agenda of the National Economic Empowerment and
203 Developments (NEEDs), Vision 2020 etc. The actualization of these programmes depended to a large extent on
204 increase public spending on infrastructure. Fiscal policy and public investment in infrastructure is built around
205 public finance theory that studies government's role in the provision of goods and services. Most literatures
206 discuss or examine the increasing government spending on varying determinants that affect trends in public
207 expenditures. Even though many such literatures examine the effects of Wagner's law. Wagner's Law states
208 that, "as the economy develops overtime, the activities and function of the of government increases". The
209 developmental agenda of government in developing countries still depends to a large extent on public finance,
210 thus follows Wagner's treatise. However, as examine by researchers to be fact that it does not show a causal
211 relationship when the examination of GDP growth is examined with public expenditure levels, (Fernandes,
212 2009), meaning that Wagner's laws did not actually measure that growth that spurs public spending overtime,
213 rather, it merely recognizes a positive statistical association between those two variables.

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215 There are evidences that a government budget deficit, which has always been reflected in Nigeria's extra
216 budgetary allocation, gives rise to adverse growth effects (Bose, Haque, & Osborn, 2007), and this has been
217 responsible to low rate of investment in transport related infrastructure over years. This have been seen in stock
218 of roads in Nigeria, especially rural roads which provides bulk of the population in rural Nigeria and has impacts

on agricultural productivity and access to markets for agricultural goods (Fakayode, Omotesho, Tsoho, & Ajayi, 2008).

Public investment in road building or other infrastructures seems not to keep pace with the growth of the economies in the Sub-Saharan region. According to (Estache, Speciale, & Veredas, 2005), Financial crisis created an infrastructure gap. Gaps resulted into high transport cost (for various transport needs), high costs of production, low quality output and other factors that impacted on the slow growth of the economy overtime (Sunil Sinha, 2011). Most large investments in infrastructure were made to reduced high cost of transportation (accessing landlocked area, or barriers like a bridge). Thus the place of infrastructure according to the world Bank is significance to growth.(Bank, 1994), but recent concerns have been raised for bulk or large means for moving goods, the Nigerian railways for instance has sub optimally function below its actually capacity compared to the early parts of Nigerian independence to 1980s. The modal share between the Nigerian railways and others road transport has dropped (Adesanya, 2010; Osuji, 2013)

3.2 Quality of infrastructure

Quality of infrastructure affects various aspects of the transport system. Quality of infrastructure affects time dimension of travel time, and the travel time affects monetary outlays – the cost dimensions. If delivery time is uncertain, it affects total transaction costs. The more uncertain is delivery, the more inventories are needed as a buffer stock if demand fluctuations are unrelated to fluctuations in delivery time. Inventories are expensive both because they bind up capital and because the value of the stored goods may depreciate over time, thus adding to inventory valuation process in a typical accounting concepts.

Measuring quality of infrastructure focuses on the country's ability to enhance the movement of both people and merchandise. Quality of infrastructure can be a proxy of costs because the researcher considers movements of goods either across the borders or within the country. According to (De, 2006), the more uncertain is delivery time, the more inventories are needed as a buffer stock if demand fluctuations are unrelated to fluctuations in delivery time. To assess the impact of infrastructure like roads on trade between countries within sub-Saharan region, an index II, - Infrastructure Index is constructed. The Infrastructure index (II) is designed to measure the cost of travel across a country. The II examines land distance to determine the cost of going through a given infrastructure, say the length in kilometres and transport prices, and measures the relative distances considering

a set of observables - commonly the geography of the transport, other barriers like customs checks and immigration requirements

In the initial use of II , an index of a country's infrastructure stocks is determined (nine variables), using Principal component Analysis (PCA). The PCA is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components.

$$II_{ij} = \sum W_{kj} X_{kij}^3$$

Where II_{ij} is infrastructure development index of the i -th country in j -th time, W_{kj} is weight of the k -th facility in j -th time, and X_{kij} = unit free value of the k -th facility for the i -th country in j -th time point.

Large volumes of studies looked at the relationship between trade and infrastructure have found a positive and significant impact of quality of infrastructure on trade (Clark et al., 2004; Wilson et al., 2003; (Lima & Venables, 2001)). For example, Clark et al. (2004) estimate that if a country like Peru or Turkey improved sea port efficiency to the level similar to Iceland or Australia, it would be able to increase trade by roughly 25 per cent. However, these studies have focused either on an overall measure of infrastructure quality or on maritime transport infrastructure. In the current study, the main concern of infrastructure is to facilitate mobility, its productivity using the road efficient access as a determinant.

4. Review of transportation policy and constraints.

The activity-based approach to travel demand analysis views travel as a derived demand; resulting from the need to pursue activities distributed in space (see Jones *et al.*, 1990). Derived demand concept establishes a direct relationship – movements resulting from economic activity. (Mokhtarian & Salomon, 2001).

Travel constraints, referring to problems that result from specific travel activity overtime. Most measurements in travel behavior are probabilistic, assigns a probability to each of the possible outcomes of a random experiment, it revolves around availability (from a choice set) of transport mode or other aspects like accessibility, connectivity. Accessibility defines cost and duration (time), connectivity is used here to mean the ability to link up another access road or a schedule transport time.

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280 3. As used by De, P. (2006) in “Empirical Estimated of Trade Costs for Asia” (see references)

281 According to (*Awoyemi, 2011*)) Nigeria has experienced many of public transport; at least last 20 years there
 282 has been increased usage of public transport. The growth in public transport has several determinants: (i).
 283 population growth, (ii).state creation that has introduced movements to some cities and evolution of some towns
 284 into ‘semi urban cities’, (iii) rise in public demand for ‘democracy dividends’ especially in mobility (mass
 285 transit buses) around towns for various needs, (iv). Vision 2020 philosophy of government, which has evolved
 286 from the NEEDs program, emphasizing the need and importance of transport sector and the need to provide
 287 government assisted transportation program. It has also evolve as a tool for empowering the private sector
 288 through providing funds for acquiring buses. These factors have been responsible for growth of mass transit
 289 programs in Nigeria. However, there was a decline in personal mobility caused by scarcity of foreign exchange
 290 and severe import restrictions (Filani and Abumere, 1992). These, amongst other factors of risks on the Nigerian
 291 roads, most transport providers were affected – thus old fleet of transport on Nigeria roads accounts for this
 292 phenomenon. The re-structuring programme by the Federal government with considerable investment in the bus
 293 fleet size had introduced the need for higher degree of mobility, since the transport policy of government
 294 estimates that about 90% of the travel needs of the people are met by road public transport in most cities (F.G.N,
 295 2010)

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297 The safety and convenience of Nigerian public transport, coupled with bad roads, due to neglects in
 298 maintenance and investment in rural roads especially, have been bottlenecks' in the realization of cardinal points
 299 of Nigeria’s transport policy. Factors that have dictated travel behavior in Nigeria are:

300 (1). Level of public investment is low compared to other regions in Sub Saharan region (see figure 1 in appendix
 301 page)

302 Figure 1.

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304 (2). High risks on the roads – arm robbery, road conditions etc.

305 (3). Maintanance of public transit and general maintenance of fleet on Nigerian roads.

306 (4). Poverty, especially in the rural sectors of Nigeria

307 (5). Arm conflicts/ethno-religious environment in most of Northern Nigeria.

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These conditons have affected travel behaviour in Nigeria in resent times, coupled with the increasing ethno-religious environment in Nigeria, the Boko Haram religious sect, elements of alquaeda threats, kidnappings etc., have constrained and change the dynamics of travels in Nigeria.

5. Conclusion.

Discrete choice models (DCM) are vital tools for assessing different models travel behaviour over the years. Most (DCMs) have been vital tools for assessing travel-based models. These models are also referred to as disaggregate and probability models because they examine individual travel choices and the degree of uncertainty.

These tools have mostly been applied to advanced market economies because of the importance of infrastructure in promoting trade and commerce. In developing economies however, most literature have been concerned with the lack of performance, growth and other inhibitions resulting from lack of adequate infrastructure to support industries and the real sector. These conditions have also affected individual travel behaviour.

The study recommends public action in two areas: Growing insecurity in the country generally, specifically some Northern Nigerian roads, and secondly the need for growth in the public-private-partnership (PPP) in road building and maintenance of existing roads.

This study is a springboard or a pointer to the fact that “A good public transport system must be easy and convenient to use, fast, safe, clean and affordable” (Kyle, 2011), that the conditions of roads are kind of empowerment tools for the populace – access educational, trade and social environments.

The major limitation of this study is the rigorous survey of models that have changed the perspective for assessing travel-based models. These can be exploited for further studies.

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Appendix

Figure 1.

