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# Assessing Road Connectivity Impact on Subjective Quality of Life Using Structural Equation Modelling

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**ABSTRACT**
The underlying influence of road transport system on societal well-being is not yet well foretold. Such predicament is prompted by limited capture of quality of life features in analysis and also due to undefined analytical model. This research introduces a novel model with multidimensional predictive approach for empirical exploration of road connectivity influence on quality of life (QOL) in Abuja City, Nigeria. Suitable road connectivity components and quality of life indicators were identified through literature review. Data were generated on the identified road connectivity social components and transport related quality of life indicators from 367 respondents in the 15 (37.5%) sampled districts. Exploratory factor analysis (EFA) was performed using SPSS 15.0 software to ascertain the components of road connectivity and quality of life indicators for model development. Structural equation modelling (SEM) was applied for confirmatory factor analysis (CFA) to determine the model fitness between the components of road connectivity and the latent indicators of transport related quality of life. Factor analysis affirmed that four connectivity components, six latent factors and 26 observable factors were fit for model development. The structural equation modelling showed high factor loading (R2 = 0.66), implying that road connectivity components explained 66% of QOL. Path coefficient was 0.81, indicating that every one unit increase in road connectivity contributes 0.81 unit increase in QOL. Hence, the study suggests a multidimensional model that can be employed for analysing transport performance. The model would be useful to researchers, planners and engineers for examining the influence of transportation network on societal quality of life.

**KEYWORDS**
road network; social components; quality of life; modelling; Abuja

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## INTRODUCTION

Road network determines the daily possibilities of people's transaction and social activity in the city (Holzapfel, 2015). This is because roads regulate how individuals gain access to facilities, leisure, places of work and organizations. A connected road network portrays some latent features that facilitate movement and networking. Such features are regarded as social components of road network which serve as drivers for quality living in cities. The social components of road network comprise route options, network efficiency, transport reliability and traffic flow as explained hereafter.

### Route Options

Route option is the opportunity and tendency for selection of various roads to a specific destination (Bovy, 2009). In other words, it is the possibility of choosing a route among alternative pathways (Ghorveh, 2017). Several factors affect commuter' route choice in metropolitan areas. These factors are generally classified into two categories: one, alternative dependent factors are those that vary as routes change such as journey distance, travel time, network aspects. Two, generic trip factors refer to attributes that are identical for a whole trip and only change between dissimilar journeys. Examples include socio-demographic features, trip drive and weather situations (Li, 2017).

Among the alternative dependent attributes, trip distance and travel time are the two most important factors in route choice decision-making (Bovy and Bradley, 1985, Howard and Burns, 2001). However, the most essential factors of significance to scholars and planners are network factors. These include traffic volume, surface gradient, and road type. Others are network reliability, number of turns, scenery, speed, safety, road surface, and comfort (Bailenson et al., 1998, Papinski et al., 2009, Li, 2017). Comfort level parameters, which describe whether travellers are comfortable during the entire route also affect route choice (Sener et al., 2009, Li, 2017). An enhanced network connectivity provides the public with a greater variety of potential routes (Tresidder, 2005, Leslie et al., 2007, Chandra and Quadrifoglio, 2013, Boonekamp and Burghouwt, 2017). In their study, Mhangara et al. (2017) found that as connectivity increases, route options and travel modes increase. Consequently, such scenario generates fundamental circulation which ensures better quality of life (Handy et al., 2003). Therefore, route options is considered as a driver of personal life satisfaction for commuters.

**Transport Efficiency**

Efficiency expresses the extent to which specific input meets the travel demand of persons in transport system. In other words, it means how well road network delivers its inputs into usefulness (Verzola, 2004), that is, the ability of transport system to achieve travel goals. It also denotes the capability of transport system to attain transportation aim such as enabling people to get to work or goods to be delivered (Isoriate, 2005). Transport infrastructure specifically road network is the main channel of urban and regional transportation. Hence, a well-connected road network generates operational efficiency of urban transportation (Giacomin and Levinson, 2015).

Urban transport efficiency is a component of road connectivity, which entails the link among urban transport system and its ability to satisfy transport demand of the community. The aggregate efficiency of urban transport system is determined by social benefits and social costs. This is evaluated based on the usual transport demand satisfaction conveyed such as accessibility, comfort, security, and swiftness. Hence higher proportion of social benefit denotes greater transport efficiency (Yuan and Lu, 2001).

**Network Reliability**

A well-connected road network permits sustainable transport system. This generates network reliability and eventually raises societal quality of life (Skach, 2016). Reliability here means the likelihood of effective movement by commuters over time from one place to another by road system (Berdica, 2002). This encompasses effective movement by pedestrian, cyclist, transit and car. In other words, reliability means the possibility of transport network to perform desired function satisfactorily over a period of time (Clement et al., 2000). Transport network reliability concepts are categorized into connectivity reliability and performance reliability (Iida, 1999). Connectivity reliability focuses on inter-urban road network; while performance reliability centres on urban network performance (Chen et al., 1999, Bell and Iida, 1997).

Network reliability is a vital performance measure for assessing urban road networks (Iida, 1999). This centres on the probability of urban road networks to perform consistently within a well-defined standard (Muriel-Villegas et al., 2016). Thus, ensuring transport reliability in urban road network has become a high priority in cities (Muriel-Villegas et al., 2016). This is because higher network reliability signifies better quality of transport system, which in turn promotes societal well-being. Connectivity, travel time, and capacity have been the three main measures mostly explored in determining network reliability performance (Chen et al., 2002).

**Traffic Flow**

Movement in the city is denoted by commute flows in and out of definite urban travel (Sarkar et al., 2017). Thus, traffic flow is the quantity of vehicles moving over a road at a given period of time (Lighthill and Whitham, 1955). It indicates the relationship between travellers and road infrastructure. Road connectivity facilitate traffic flow and transport accessibility within a geographic setting (Vaidya, 2003; Scaparra and Church, 2005; Cheng and Panichpapiboon, 2012). More so, connectivity ensures efficient traffic flow in road network. Free flow, that is, unrestricted stream of traffic drifting along a pathway signifies efficient traffic flow. This is vital for faster circulation, connection and transaction (Devi and Neetha, 2017). Thereby playing a significant role in determining the scope of improvement in urban traffic operation.

Although traffic flow is predominantly validated based on floating vehicle survey. It is as well appraised using empirical analysis, that is, by observation and mathematical curve fitting (Bedogni et al., 2015). Self-reported assessment – observation technique is another factual, easy and reliable method of driving information on traffic flow. This is because what is observed is specific, recent and critical (Stacey and Wilson, 2014). Considering the foregoing synopsis, route options, network reliability, transport efficiency and traffic flow are acknowledged as the relevant and essential social components of road connectivity. Hence, in this study they were adopted to serve as connectivity social predictors of personal quality of life.

**Transportation Related Quality of Life Indicators**

Quality of life can be considered as an aggregate construct of various specific spheres of life. Satisfaction in life is achieved as a result of fulfilment in attributes of the respective domains of life (Lee 2008; Rojas 2008). Road network connectivity plays a key role in promoting quality of life (Parida, 2014). Such function is often verified by evaluating diverse impact indicators. Indicators here refer to variables that represent or measure the social and economic progress generated by road network system. Variables that can be quantified in monetary term are known as economic indicators. Variables that are more concerned with people's quality of living are referred to as social indicators (Horn, 1993). Examples include life contentment or pleasure which are used to assess internal experience of individual quality living by self-reporting (Spinney et al., 2009). Eminent indicators of transportation related subjective quality of life were identified from literature as reviewed hereafter. In this research, they have been adopted as main variables of quality of life.

**Travel Safety**

Safety literally means freedom from harm such as accident and harassment during journey. In order words, it refers to the ability of transport system users to reach their destination safely on any given trip (Program et al., 2009). That is travelling at liberty and being free from passionate crime, assault and material theft (Rahman et al., 2011). Safe travel for all road users is a necessity to ensure sustainable and inclusive city. Provision of safe transport network is the prime goal of sustainable transport, as risk of injuries and fatalities from traffic accidents is now a major public health concern globally (Tiwari, 2014).

The safety of people is considered as essential indicator and measure of the benefit of transport infrastructure (Tiwari and Jain, 2012). Hence, it appears to be a prime sort in discoursing transportation allied QOL predicators (Schneider, et al., 2013). It is unanimously supported that travellers' safety need to be guaranteed during all lengths of trip: on vehicles, during the waiting time, and on access routes to stations and stops (Tiwari, 2014). Thus, safety is a vital domain of quality life (Rahman et al., 2011). Especially personal safety which refers to individual concern or feeling of freedom (Schneider, et al., 2013). Several variables are used to determine the influence of transport network on travel safety.

**Social Interaction**

Social interaction denotes the successive contacts which regularly occur between sets of people (Pastor-Satorras, 2017, Starnini et al., 2017). The ability of individuals to partake in broader community activity is a robust determinant of well-being (Reardon and Abdallah, 2013). Those who participate in outdoor social activities with other people have more satisfied lives (Spinney et al., 2009). Social interactions stimulate trust, solidarity, reciprocity and positive feeling among citizens in the community (Leyden, 2003, Matarrita-Cascante et al., 2006, Jennings and Krannich, 2013). Hence providing access to quality interactions is a necessity for social and emotional well-being. Road network has strong influence on social interaction especially in urban setting (Bawa-Cavia, 2010). It offers opportunity for better physical exercise which can lessen stress, obesity and other cardio-vascular illnesses. Access to sport and recreation facilities encourage active lifestyles (HaringeyCoreStrategy, 2010). Several variables are used to determine the influence of transport network on social interaction (Goetzke et al., 2015). Such includes road access to leisure activities, friends, family members, social groupings, and participation of people in civic life (Miciukiewicz and Vigar, 2012). Thus, satisfaction with road access to community meetings, social association gatherings, religious activities, relatives and friends, out-door sports, recreational parks, places of entertainment and public transport system have been identified as variables of road network social interaction.

**Economic Well-Being**

Road network contributes considerably to economic well-being, which is essential for social development of urban community. It instigates economic growth by intensifying and repositioning business transactions, rise in the number of income-earners, increase in income, ease access to business parks, local retail and hospitality establishments (CTAA, 2012). Improvement in urban road connectivity and density attract variations in travel forms, expenditure forms and locality attraction. This in turn has positive effect on trade and property owning, by having direct influence on retail transactions, retail fees, office charges, and commercial property values (Meisel, 2010).

Better road network attracts more people and activity, creating more economic opportunities. This generates increase in retail sales which is a direct indicator and strength of local economy in urban society (NYCDOT, 2014). It also enhances access to market, capital and idea (Maparu and Mazumder, 2017). Similarly, a commercial cluster with an extended road system and good road interconnection is allied with better reception area in cities (Huang et al., 2017). Several variables are suggested to be considered in assessing the influence of urban road structure on economic well-being. Such includes business opportunity, supply of local consumers' demand, travel cost and time saving, increase in income, and local economy agglomeration (Maparu and Mazumder, 2017).

**Travel Comfort**

Comfort is described as a state of feeling or affective reaction (Richards et al., 1978). The term is synonymous to satisfaction, which means travellers' satisfaction with journey. Comfort in travel refers to travellers being contented and happy during journey (Garcke, 1939; Oborne, 1978). Mayr (1959) identified the three sub factors of travel comfort – riding comfort (physiological and psychological factors), local comfort (stationery and facility factor) and organisational comfort (connectivity and service reliability). Garcke (1939) also distinguishes between mental and bodily comfort. He proclaimed that mental comfort is freedom from psychological strain and worry; while bodily comfort means safety from physical strain or fatigue.

The level of travel comfort depends on travel purpose, time, cost, and commuter's expectation of travel comfort (Oborne, 1978). Improvement in road surface, network connectivity and density leads to optimization of travel comfort. Gorter et al. (2000) advocates that complexity and multidimensionality of network influences travel comfort and is subjective in nature; hence cannot directly be observed. It is only indexed by rating scale through commuters' feeling checked using qualitative description (Richards et al., 1978). Enhanced travel comfort is a social indicator of road network quality of life. Thus, significant components of travel comfort (Physiological, psychological and facility factors) are employed to assess the impact of road network on commute quality of life. This is reflected through self-reporting on satisfaction with facility, traffic flow, route and mode choices, road condition, scenery and road infrastructure (Ayachi et al., 2015).

**Personal Accessibility**

Accessibility refers to the ease with which places or facilities could be reached by people (Lotfi and Koohsari, 2009). In other words, it entails the ability to contact or arrive at various opportunities or functions of interest such as jobs, activities and destinations (Høyer, 1999, TDM, 2015). This implies the possibility of individuals to access desired destinations in order to satisfy wants or participate in activity (Schneider, 2013). Accessibility is also recognized as personal ability to reach destinations to carry out activity by transport network (Bhat, 2000, Seu, 2003). This concept is denoted as personal accessibility; a latent notion derived from various indicators determined by diverse units of measurement through indirect quantification (Plomp, 2012). Thus, offers more avenue for further investigation on personal accessibility. Since the most essential purpose of transport system is to offer the opportunity for individuals and goods to physically access wanted destinations (Caltrans, 2006).

**Personal Mobility**

Mobility as movement; is the real procedure or practice of people's move from a location to another in pursuance of day-to-day routine activities (Hanson, 2010). It is defined as actual trip-making by individuals (Mollenkopf et al., 2005) or the ability to travel from a point to another (Caltrans, 2006), that is, the physical movement to get to desired destinations (Schneider, 2013). This is essential for human existence as it ensures economic and social activities. People move in order to survive and develop societies that produce satisfactory social and cultural quality of life (Høyer, 1999). Mobility is as well regarded as personal mobility, that is, a potential for satisfying certain needs. Personal mobility can be distinguished into those which are obligatory and those which are discretionary. Obligatory trips are connected to a person's need to fulfil a role in society or family. Discretionary trips are those related to personal development and satisfaction (Hillman et al.,1973).

Rise in living standard entails increase in extent of personal movement. The extent of mobility is used to determine economic attainment which is categorized into two: personal mobility of people, that is, non-work travel purposes, and the mobility of services and goods through commercial activities (Vickerman, 1995). Increased mobility, that is, physical movement to destinations signifies progress and better standard of living. In this regard, much priority is often given to improvement of mobility by enhancing both the means (vehicle) and the way (route, path, or line) in modern cities.

Personal mobility is a vital index of subjective well-being (Spinney et al., 2009). However, it is not easily observed directly; thus, is measured using revealed mobility usually evaluated based on what has taken place or self-report of an existing situation (Spinney et al., 2009). This study adopts the term personal mobility to connote and assess satisfaction with activity travel for personal development. Some basic elements of mobility accessed include journey suitability, expediency (convenience) and immediacy or quickness (Yen and Wu, 2016).

**MATERIALS AND METHOD**

This research aimed at examining the impacts of road connectivity on subjective quality of life. In due course, appropriate road connectivity components and transport related quality of life indicators were identified through literature review.

Then questionnaire was design and used to collect data on the respondents' opinion and satisfaction with road connectivity components and quality of life indicators. Fifteen (37.5%) out of the forty districts within Abuja city were sampled in which 388 questionnaires were distributed to respondents. Thirteen (13) questionnaires were not retrieved from the respondents while eight (8) of those retrieved had about 70% - 80% missing data, so were not considered valid for analysis. At last, 367 questionnaires were found valid, coded, screened and analysed using SPSS 15.0 software to generate information on road connectivity performance and transport related quality of life indicators. AMOS 19.0 was used for confirmatory factor analysis to develop the model and to affirm the impact of road connectivity on subjective quality of life.

**Preliminary Analysis**

The fundamental preliminary analysis of normality test was performed to define the distribution of dataset. The result in Figure 1 indicates that the entire response cases in this research were normally distributed with the mean of 89.18 and Standard deviation of 23.392. Furthermore, the Kurtosis and Skewness statistical values were generated and it affirmed that about 98.56% response cases were found within the tolerable range of ±1.96 for analysis in this investigation.

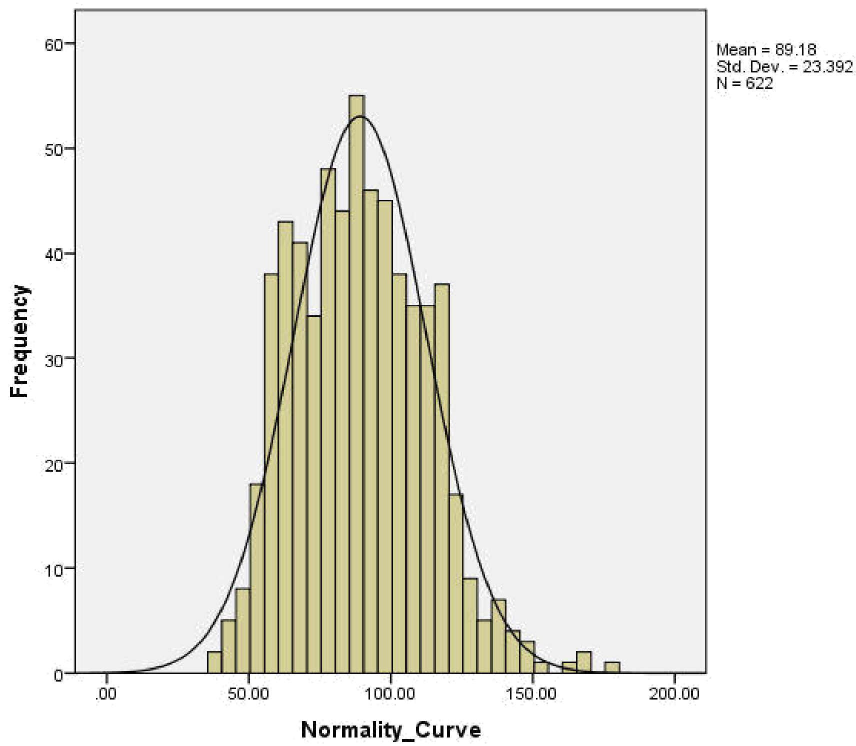


**FIGURE 1:** Normal Distribution of Response Cases.

Outlier test, which is the checking of observation that is distant from other observations of respondents was also conducted. This was examined using SPSS box plot approach to ensure that the dataset is valid. Result of this statistical test indicated no extreme cases of outlier detected in the dataset. The few minor cases of outlier values were traced back to the variables in the data record. Such cases were found to be caused by wrong data entries which were corrected. After which the box plot test was repeated and no outlier cases were discovered again in the dataset.

**Reliability Test**

Reliability test was performed to determine inter-item correlations and internal consistency of all the indicator variables. The items verified comprise road connectivity components including route options (RDCON1), network reliability (RDCON2), transport efficiency (RDCON3), and free traffic flow (RDCON4). Also examined was the reliability of quality of life indicators. These included personal accessibility (ACES), personal mobility (MOBL), emotional travel safety (SAFE), travel comfort (COMF), economic well-being (ECON) and social interaction (SOCL). The result of reliability test presented in Table 1 reveals that all main indicator variables (represented in bold digits) were above the threshold of 0.7 Cronbach alpha coefficient. The result also showed that the overall inter-item correlations of variables have reliable scale of greater than (0.5) the threshold of reliability. Therefore, the variables were grouped into seven main factors tagged as latent indicators. The individual items represented measurable sub-factors. Thus, both the main (latent) factors and sub-factors of road connectivity components and quality of life had the ability to measure the perceived phenomenon.

**TABLE 1:** Test of Reliability.

| Item | Label | Inter-Item Correlation | Cronbach's Alpha |
|---|---|---|---|
| RDCON1 | Road network enables multiple route options. | .686 | **.879** |
| RDCON2 | Roads are reliable for all transport modes. | .720 | |
| RDCON3 | Road network fully satisfy transport demands. | .762 | |
| RDCON4 | The road network permits swift traffic flow. | .754 | |
| ACES1 | Easy to reach shopping precinct. | .702 | **.891** |
| ACES2 | Easy to reach job location. | .736 | |
| ACES3 | Easy to reach hospital/clinic. | .781 | |
| ACES4 | Easy to reach primary/secondary schools. | .703 | |
| ACES5 | Easy to travel directly to different destinations. | .672 | |
| COMF1 | Public transport operation is satisfactory. | .554 | **.826** |
| COMF2 | Feel comfortable walking along roadways. | .815 | |
| COMF3 | Feel convenient vehicular trip along roadways. | .720 | |
| COMF4 | Road network layout is emotionally appealing. | .667 | |
| COMF5 | Bus-stop supply is satisfactory on roadways. | .721 | |
| COMF6 | Convenient seating arrangement at bus-stops. | .692 | |
| ECON1 | Roadways create retail business opportunity. | .757 | **.880** |
| ECON2 | Roadside shops satisfy local consumer needs. | .758 | |
| ECON3 | Roadside retail reduces travel cost to market. | .682 | |
| ECON4 | Roadside shop renting increases local earning. | .705 | |
| ECON5 | Road retails certify local group economy. | .602 | |
| ECON6 | Roadside shops ensure lovely environment. | .579 | |
| MOBL1 | Physical layout of road network is satisfactory. | .557 | **.820** |
| MOBL2 | Satisfactory route options to destination. | .759 | |
| MOBL3 | The roads enable different travel mode choices. | .717 | |
| MOBL4 | The roads facilitate easy personal movement. | .703 | |
| MOBL5 | Public transport cost is bearable. | .485 | |
| SAFE1 | Feel emotional safe walking along roadways. | .673 | **.791** |
| SAFE2 | Feel safe cycling on the roadways. | .691 | |
| SAFE3 | There is less traffic accident on the roadways. | .582 | |
| SAFE4 | Less attack of road users during night trip. | .556 | |
| SAFE5 | Less road robbery during night trip. | .582 | |
| SAFE6 | Less & bearable road traffic noise. | .545 | |
| SOCL1 | Access to community meetings. | .808 | **.907** |
| SOCL2 | Access to social association gatherings. | .777 | |
| SOCL3 | Access to religious activities; worship centres. | .688 | |
| SOCL4 | Easy visit to family members and friends. | .662 | |
| SOCL5 | Accessibility to out-door sports (games). | .721 | |
| SOCL6 | Access to amusement and recreational parks. | .676 | |
| SOCL7 | Access to places of leisure and entertainment. | .745 | |
| SOCL8 | Access to public transportation system. | .697 | |

**Sample Suitability**

Sample suitability test was conducted using Kaiser-Meyer-Olkin (KMO) and Bartlett's test to ascertain whether the answers given and the strength of relationship between the variables were satisfactory. The result presented in Table 2 indicates a sample acceptability of 0.913 which is higher than the threshold of 0.7 Cronbach alpha coefficients. This implies that the responses by participants and the power of association among the indicator variables were adequate for analysis.

**TABLE 2:** KMO and Bartlett's Test.

| KMO and Bartlett's Test | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .913 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 15425.684 |
| | df | 741 |
| | Sig. | 0.000 |

**Exploratory Factor Analysis**

Exploratory factor analysis (EFA) was adopted in order to examine the relevance and group factor variables into components and also to test their validity and contribution to the perceived model. Factor extraction was computed based on the following specifications: principal component extraction, varimax rotation, threshold for factor extraction of Eigen value >1. Only factors with loading more than 0.7 were retained as recommended by Jolliffe (2002). The result of EFA in Table 3 reveals the seven rotated component matrices extracted from the forty-one (41) indicator variables identified through literature review. Each of these components formed a cluster of variables. Of which road connectivity component (RCON1, RCON2, RCON3, and RCON4) formed a unit. Six latent indicators of quality of life (unobservable-factors) were established comprising social interaction, personal accessibility, economic well-being, personal mobility, travel comfort and travel safety.

Thirty-seven (37) observable (sub-factors) indicators were initially identified. However, based on the factor loading cut off point of 0.75 adopted in this study, eleven (11) items represented in bold digit (Table 3) were found to have low factor loading. Thus, these eleven (11) observable (sub-factors) fail to meet the required standard for consideration in this research. Such items are recommended for deletion. The items affected includes COMF1, COMF5, COMF6, ECON6, MOBL1, MOBL3, MOBL5, SAFE4, SAFE5, SAFE6, and SOCL6. After deleting these 11 low factors loading items, the observable factors were reduced to twenty-six (26) variables for modelling. The final result of respondents' personal judgement on performance of road connectivity components and quality of life indicators is presented in Table 3.

**TABLE 3:** Summary of EFA for Connectivity Components & QOL Indicators.

| Latent (Unobservable) Factor | Item Code | Measuring Factor Survey Statement | Factor Loading |
|---|---|---|---|
| Road Connectivity | RCON3 | Road network satisfies transport demand | .896 |
| | RCON4 | Road network permits swift traffic flow | .867 |
| | RCON2 | Road network is reliable for all travel modes | .833 |
| | RCON1 | Road network enables multiple route options | .832 |
| Personal Accessibility | ACES3 | Easy to reach hospital and clinic | .899 |
| | ACES4 | Easy to reach primary & secondary schools | .857 |
| | ACES2 | Easy to reach job locations | .854 |
| | ACES1 | Easy to reach shopping precincts | .784 |
| | ACES5 | Ease direct travel to different destinations | .776 |
| Travel Comfort | COMF2 | Feel comfortable walking along the roadways | .905 |
| | COMF3 | Convenient vehicular trip on the roadways | .841 |
| | COMF4 | Road layout is emotionally appealing | .840 |
| Economic Wellbeing | ECON2 | Roadside shops satisfy consumer needs | .880 |
| | ECON1 | Roadway retails create business opportunity | .868 |
| | ECON3 | Roadside retail reduces travel cost to market | .825 |
| | ECON4 | Roadside shop renting rises local earning | .807 |
| | ECON5 | Road retailing ensure local group economy | .766 |
| Personal Mobility | MOBL4 | The roads ease personal movement | .904 |
| | MOBL3 | The roads ease travel by different modes | .898 |
| | MOBL2 | Satisfactory route options to destination. | .889 |

| Latent (Unobservable) Factor | Item Code | Measuring Factor Survey Statement | Factor Loading |
|---|---|---|---|
| Travel Safety | SAFE1 | Feel emotionally safe walking on roadways | .818 |
| | SAFE2 | Psychologically safe to cycle on roadways | .791 |
| | SAFE3 | There is less traffic accident on the roadways | .757 |
| Social Interaction | SOCL1 | Ease access to community meetings | .836 |
| | SOCL7 | Ease access to places of leisure | .815 |
| | SOCL3 | Ease access to religious worship centres | .814 |
| | SOCL4 | Ease visit to family members and friends | .808 |
| | SOCL5 | Ease access to out-door sports (games) | .787 |
| | SOCL2 | Ease access to association gatherings | .775 |
| | SOCL8 | Ease access to public transportation system | .764 |

**Confirmatory Factor Analysis Using Structural Equation Modelling**

Structural equation modelling (SEM) is a flexible and extensive statistical method used in complex multivariate research models. In this study, SEM was applied using analysis of moment's structure (AMOS) to develop a conceptual model for assessing the influence of road connectivity components on quality of life. The concepts of structural equation modelling, the measurement model and test of the research outcomes are illustrated under results and discussion.

**RESULTS AND DISCUSSION**

**Estimate of Quality of Life Measurement Variables and Hypotheses**

The conceptual model of this study is established on "Connection Theory" which posits that transport network connectivity improves the living standard of people in the community (Jackson and Wolinsky, 1996). The model was developed based on reviewing selected literature on the latent (unobservable) and measurable (observable*)* factors of road transport related quality of life indicators as illustrated in Figure 1. The latent (unobservable) factors signifying dependent constructs or factors are enclosed by ellipse. The curved, double-headed line between two factors indicates covariance, that is, they are correlated (Schumacker and Lomacax, 2004). Each latent factor is measured by a number of observable (independent) variables. These measurable variables are represented by rectangles. Every latent factor has single headed arrows pointing toward their respective measurable variables. Each measuring variable or item has an error term – a number enclosed by circle with one directional arrow pointing towards a specific variable. The error terms quantify the random error that influences an observed variable. Another vital aspect of structural equation modelling is model fit estimation. The five fitness indices selected for model fit estimation in this study are shown in Figure 2. Such includes RMSEA (Absolute fit), CFI, NFI, TLI (Incremental fit) and CMIN (parsimonious fit). These fit indices were complimented by *P*-value of the model.

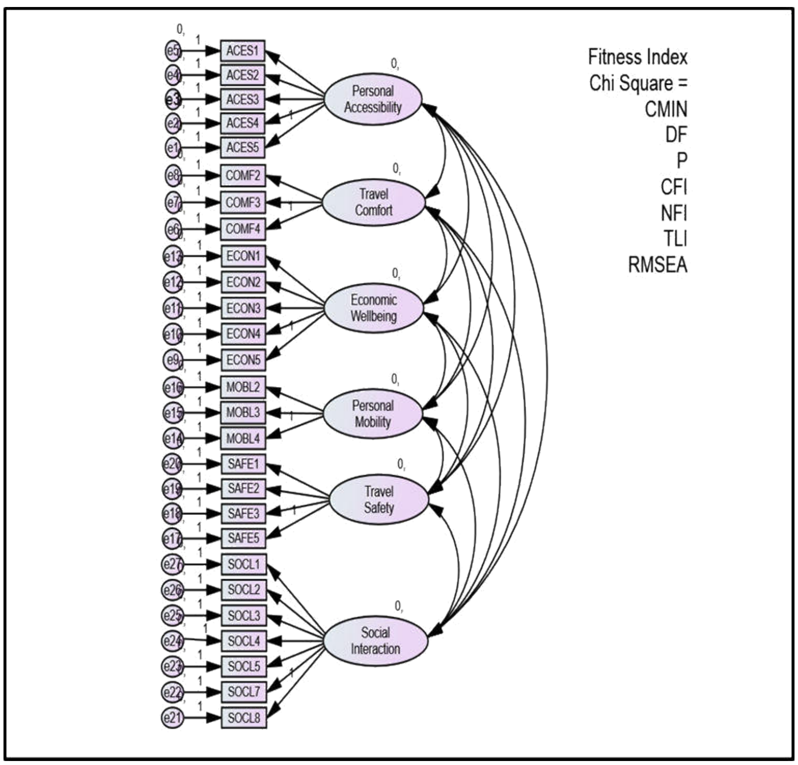


**FIGURE 2:** Estimate of Confirmatory Factor Analysis Measurement Model. ACES1, ACES2, ACES3, ACES4, ACES5 measure Personal Accessibility. COMF2, COMF3, COMF4 measure Travel Comfort. ECON1, ECON2, ECON3, ECON4, ECON5 measure Economic Well-being. MOBL2, MOBL3, MOBL4 measure Personal Mobility. SAFE1, SAFE2, SAFE3, SAFE5 measure Travel Safety. SOCL1, SOCL2, SOCL3, SOCL4, SOCL5, SOCL7, SOCL8 measure Social Interaction.

**First Order Confirmatory Factor Analysis (CFA) Model for Quality of Life Variables**

First order confirmatory factor analysis was performed to verify the convergence and discriminant validity of quality of life indicator variables as illustrated in Figure 3.

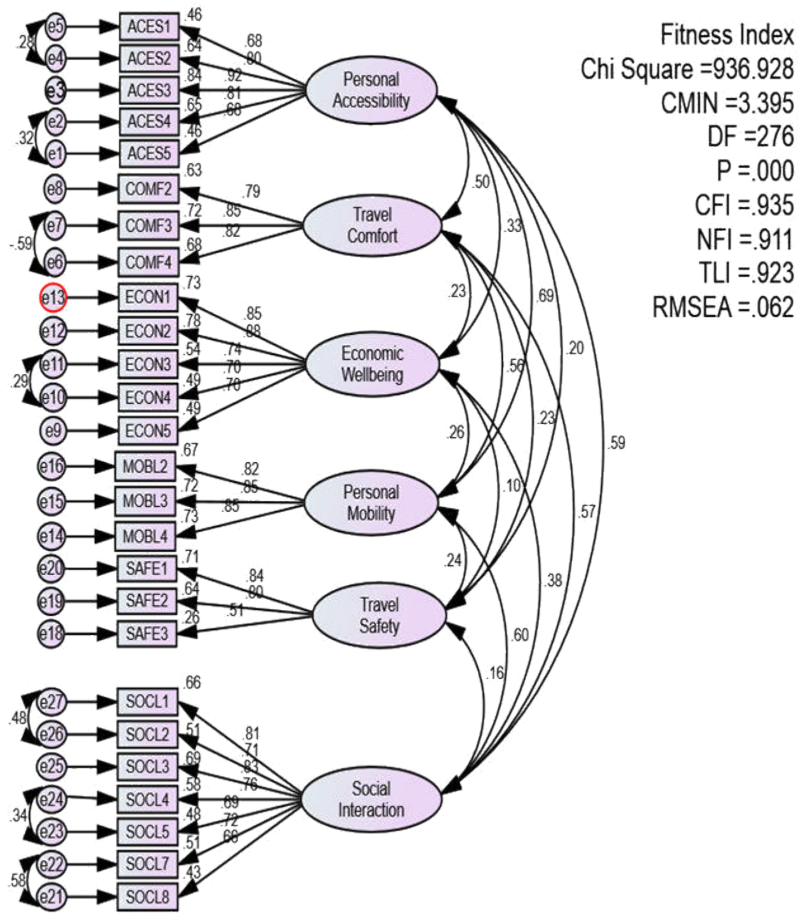


**FIGURE 3:** First order confirmatory factor analysis model. The measurement model variables (e.g. ACES1, ACES2, ACES3) are presented in squares; the first order latent variables (e.g. Personal Accessibility, Travel Comfort) are presented in ovals. The numbers on arrows between variables are coefficients. The number at the far left (e.g., e5, e4, e3) represents the residual variance not explained by the latent variables.

The road users' quality of life CFA data in Figure 3 specify that fit indices were above the necessary cut-off values of CMIN ≤ 5, CFI, NFI, TLI > 0.90 and RMSEA < 0.08. Accordingly, RMSEA = 0.062, CMIN = 3.795, CFI = 0.935, NFI = 0.911, TLI = 0.923. The unidirectional arrows pointing from latent factors (Personal accessibility, Personal mobility, Travel comfort, Travel safety, Social interaction and Economic well-being) to the respective measuring variables are known as factor loadings - ranging from 0.51 – 0.92. These figures signify the strength of relationship between each latent (unobservable) factor and the respective observable factor indicators.

The double headed arrows indicate the extent of correlation between the various latent factors. Result reveals that convergence hold between the six (personal accessibility, personal mobility, travel comfort, travel safety, economic well-being, social interaction) latent factors. Personal accessibility and Personal mobility have the strongest (0.69) covariance coefficient. This is followed by Personal mobility and Social interaction with 0.60 coefficient. Next is Personal accessibility and Social interaction (0.59). Economic well-being and Travel safety have the lowest (0.10) correlation. Thus, both results of fit indices and covariance affirm that the six (personal accessibility, personal mobility, travel comfort, travel safety, economic well-being, social interaction) factors conveniently measure road users' subjective quality of life.

**Second Order Confirmatory Factor Analysis (CFA) Model for Quality of Life Variables**

The second stage model known as second order confirmatory factor analysis performed in this study is displayed in Figure 4. Quality of life was the main construct (higher order factor), while the six latent factors (sub-constructs) formed the lower order factors. The basic information elucidated in Figure 4 is the squared multiple correlation coefficient (R2), that is, the effect quality of life exerts is indicated with figures above the respective latent (unobservable) factors. Personal mobility has the highest (.67) effect value.

This is followed by Personal accessibility (.63), Social interaction (.58), Travel comfort (.45), Economic well-being (.15), and Travel safety (.07), which stand as items or variables. The combined values from these items were utilised to estimate the higher order factor of road users' quality of life in the present model.

From the result, Personal mobility having the highest (.67) effect value, imply that road connectivity highly promotes personal mobility in Abuja city. Travel safety has the lowest (0.07) effect value. This indicates that road network performs less in supporting emotional travel safety. Specifically, there is inadequate psychological safety while walking and cycling on the roads. There is also unsatisfactory freedom from traffic accident on the roadways. Such outcome could be attributed to the lack of adequate incorporation of sustainable transport (Walking, Cycling and Transit) into the road network design of Abuja city. This should be an area of serious concern to transport planners and engineers in the city. Especially as interest globally is recently directed towards promoting road network design with pedestrian, cycling and transit routes in cities for healthy environment and inclusive urban growth.

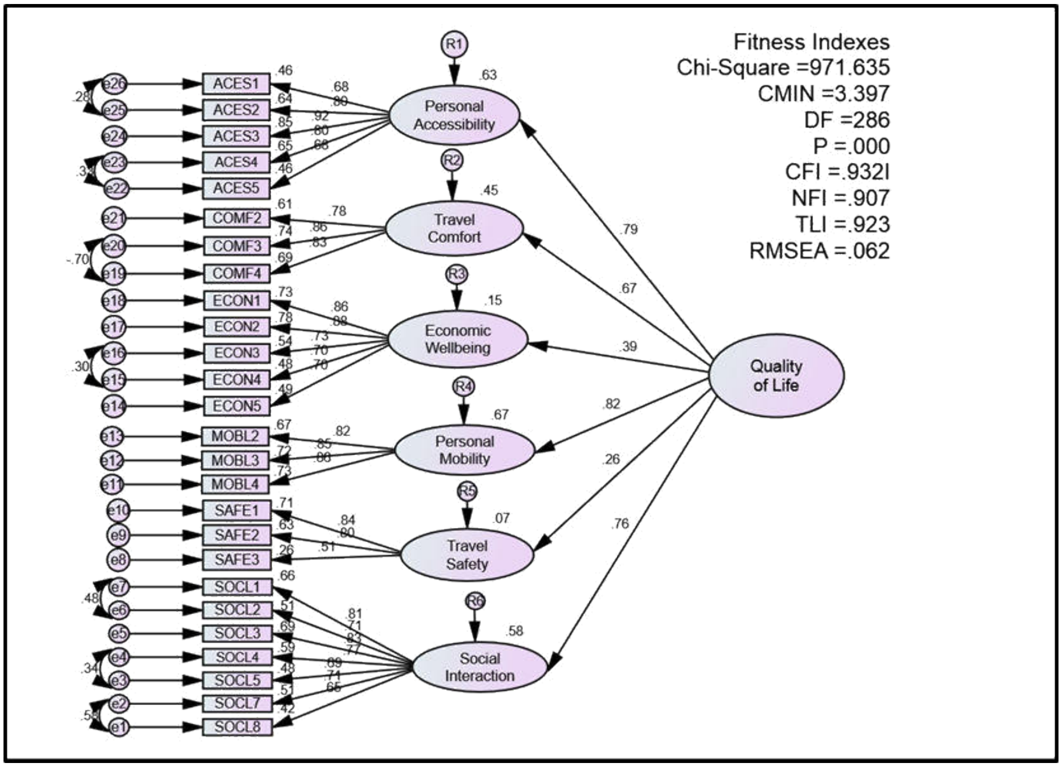


**FIGURE 4:** Second order confirmatory factor analysis model. The six factors (the first order latent variables) are explained by a broader dimension of quality of life (the second order latent variable). In other words, we hypothesized that Quality of Life would influence road user's, Personal Accessibility, Travel comfort, Economic Well-being, Personal mobility, Travel safety and Social interaction, and the hypothesis was accepted. The number that points to each latent variable at the far left (e.g., e26, e25, e24) represents the residual variance not explained by the latent variables.

Figure 4 illustrates the fit indices for quality of life perception second order model. It reveals that the selected indices: CMIN = 3.397, CFI = 0.932, NFI = 0.907, TLI = 0.923 and RMSEA = 0.062, are within the admissive fitness thresholds of CMIN = ≤ 5, CFI, NFI, TLI = > 0.90 and RMSEA = < 0.08 correspondingly. Another information elucidated in Figure 4 is Path coefficient which denotes the strength of relationship between the main construct and sub-constructs. The regression path (unidirectional arrow) coefficient between quality of life (exogenous) factor and the six (personal accessibility, travel comfort, economic well-being, personal mobility, travel safety, social interaction) endogenous factors suggest that the correlation among quality of life, the six sub-factors and their respective measuring variables are significant.

The result shows that Personal mobility has the highest (.82) beta coefficient. This is followed by Personal accessibility (.79), Social interaction (.76), Travel comfort (.67), and Economic well-being (.39). The least is Travel safety with.26 coefficient. The fact that Personal mobility has the strongest association with quality of life implies that road connectivity improves personal mobility more than the other aspects of quality of life indicators in Abuja city. This outcome is consistent with Spinney et al. (2009) and Metz (2000) discoveries that transport mobility is highly linked with quality of life domains. The overall result clearly reveals that the contribution of quality of life measuring variables on the respective six latent factors is generally good. Hence, the model that quality of life consists of six sub-constructs is well supported.

**Structural Equation Model CFA of Road Network Connectivity Components and Subjective Quality of Life**

Structural CFA was carried out in order to determine the influence of road connectivity on subjective quality of life. In which road connectivity social components (RDCON1, RDCON2, RDCON3 and RDCON4) served as predictor (independent) while the subjective quality of life indicators served as endogenous (dependent) variables. Figure 5 present the squared multiple correlation and the path coefficient. The squared multiple correlation (R2) coefficient is the relationship between endogenous (dependent) construct's actual and posited value (Hair et al., 2012). It entails the collective effects of exogenous (independent) constructs on the endogenous (dependent) constructs.

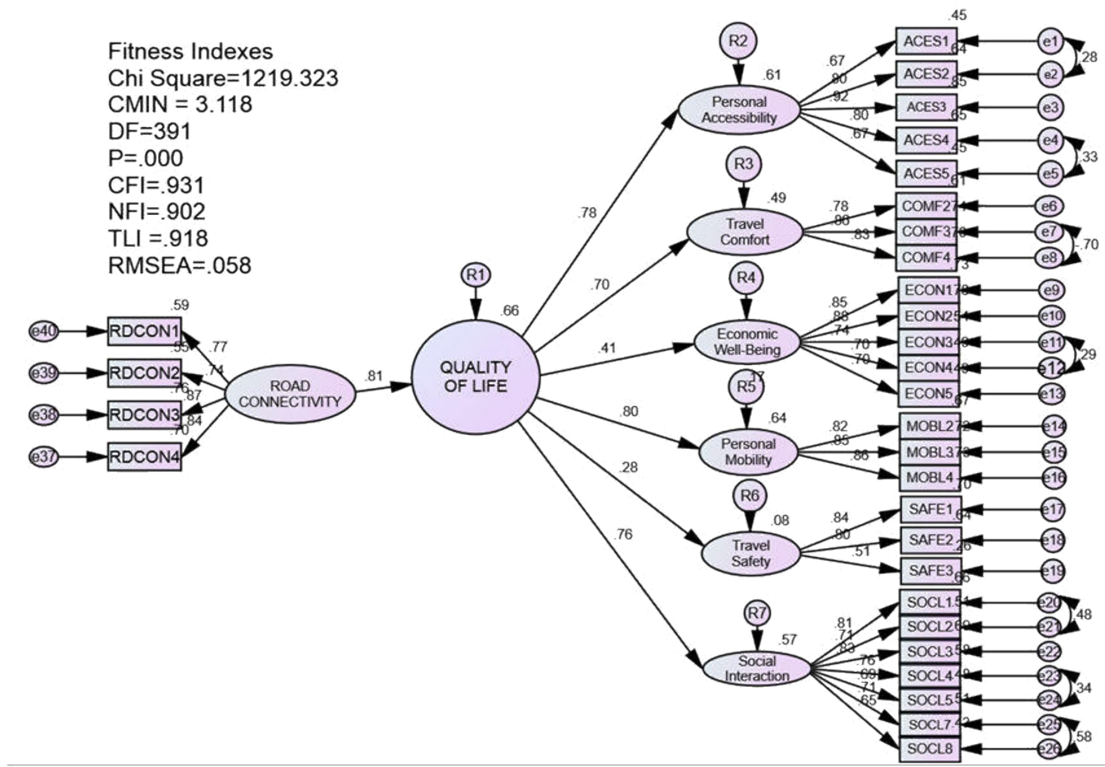


**FIGURE 5:** CFA Model of Road Connectivity and Quality of Life. Four road connectivity social components (route options, transport efficiency, network reliability and traffic flow) influence quality of life indicator (Personal Accessibility, Travel comfort, Economic Well-being, Personal mobility, Travel safety and Social Interaction). In other words, we hypothesized that road network connectivity improves the living standard of people in the community by promoting personal accessibility, travel comfort, economic well-being, personal mobility, travel safety and social interaction, and the hypothesis was accepted.

The measurement CFA model in Figure 5 shows that all fitness indices (RMSEA = 0.058, CMIN = 3.118, CFI = 0931, NFI = 0.902, TLI = 0.918) are within the acceptable thresholds. The factor loading of the latent constructs range from 0.28 – 0.80. That of observed variables ranges between 0.51 and 0.90, much above the requisite threshold. The effect of Road Connectivity on Quality of Life is highly (0.66) significant far above the threshold value of 0.20. This implies that Road Connectivity items explained 66% of quality of life. In other words, 66% of the information on Subjective Quality of Life has been explained by Road Connectivity Components in the current model. Otherwise, 34% of the variance have neither been accounted for nor explained in the model.

The path coefficient of Road Connectivity Components to Subjective Quality of Life is 0.812. This means that for every one unit increase in Road Connectivity, its effect would contribute 0.812 unit increase in Subjective Quality of Life. Hence, the overall model supports that Road Connectivity has significant and positive influence on Subjective Quality of Life in Abuja city. This is in line with Gao et al (2016) finding that street connectivity improves the well – being of urban dwellers. The result of this research supports the "Connection Theory" which posits that transport network connectivity improves the living standard of people in the community (Jackson and Wolinsky, 1996, Yang et al., 2009).

**CONCLUSION**

This research sought to contribute towards understanding the effect of urban transport network on societal well-being. It provided a model for assessing the influence of road connectivity on quality of life. The approach provides a new robust transport assessment technique which can help in improving our understanding on the relevance of road network to quality living and eventually support policy and practice in the future. The study has established that road network connectivity facilitates quality of life. This implies that urban quality living is established on the capability to grasp a diversity of economic and social possibilities. Since the benefits of transport tend towards making greatest use of roads, proposal for road transport development should focus on overcoming the breach between the advantaged and disadvantaged urban areas. Transport engineers and planners ought to embrace procedure which precisely meet the need of the deprived sectors of the community. Such action will warrant equity and enhance potentials to the entire urban dwellers.

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