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# TRANSPORTATION EXTERNALITIES REDUCTION AND RIDERSHIP OF BUS RAPID TRANSIT (BRT) IN LAGOS METROPOLIS

Suraju Abiodun Aminu and Olugbenga Ezekiel Pearse

Department of Marketing, Lagos State Polytechnic, Ikorodu, Lagos state, Nigeria

## ABSTRACT

The chaotic, unreliable and uncoordinated public transport (PT) system in Lagos and other states in Nigeria has made ownership of personal vehicles attractive to a growing number of people. This has resulted in many motorists preferring to make trips in a personal, rather than in a public mode. Unfortunately, heavy dependence on a private mode of transportation imposes externalities (adverse effects) on the people and the environment. This paper investigated whether motorists' decision to ride on Bus Rapid Transit (BRT) is related to their quest to reduce these adverse effects in Lagos metropolis. We collected data through questionnaire and observation. Data were obtained from a valid sample of 926 drivers-turned riders along the new Ikorodu-CMS corridors. Multiple regression analysis was used to analyze the data. Observation was used to collect data that either could not be collected by survey or could be biased by it. The survey results showed that ridership of BRT by motorists in the Lagos metropolis can be predicted by their desire to reduce transport externalities such as traffic congestion, gasoline consumption, emissions and health hazards. The most profound of the observation results is the significant reduction in traffic congestion observed along Mile 12- Ikorodu road, hitherto notorious for severe traffic congestion. It was concluded that as more motorists become more environmentally responsible, they will choose to ride in BRT in the metropolis.

**Keywords:** Bus Rapid Transit, Personal Vehicles, Public Transport and Transportation Externalities.

## INTRODUCTION

In marketing, transportation is one of the four elements of physical distribution management (PDM), otherwise referred to as supply chain management. Other elements include customer order processing, inventory control and warehousing. Transportation is crucial for the movement of people and goods and within and outside a country. With respect to the movement of people, a considerable number of people, especially those on the lowest rung of the ladder (the masses) in urban and sub-urban areas in different countries, depend largely on public transport (PT) for mobility. However, a growing number of individuals owing vehicles can choose between making trips through a personal mode or a public mode.

Due to speed, comfort, convenience, security and privacy provided by the private mode (Basso & Oum, 2007), majority of vehicle owners predominantly travel in their personal vehicles in most major cities of the world, causing severe externalities (external costs) to the people, environment and infrastructure (Aminu, 2016) and avoidable fiscal and financial burdens to governments around the world. Unfortunately, Lagos roads are predominantly plied by private vehicles due to chaotic, unsafe, dilapidated and inefficient PT in the state.

One of these externalities is traffic congestion (Okanlawon, 2007; Minett & Pearce, 2011). Excessive use of personal vehicles, in a megacity like Lagos, causes severe traffic congestion. Little wonder that Lagos has a serious traffic situation in the country with commuters spending hours, in the peak periods, to get to their destinations. Another externality of travelling in a personal mode is higher fuel consumption (Badmus, Osunleke, Fagbenle, & Oyewole, 2012; Clerides & Zachariadis, 2008). The consequence of a high number of personal vehicle ownership in the state is inordinate consumption of fuel. Jaja (2010) estimated the fuel consumption of the 36 States in Nigeria and reported that Lagos accounted for 25 percent of the total fuel consumed between 1975 and 2005. The growing petrol consumption, until recently when international prices of crude oil fell, constituted a fiscal burden to the successive Nigerian governments (Aminu & Olayinka, 2014a).

Excessive use of fuel also emits greenhouse gases (GHGs) such as carbon-dioxide, nitrogen dioxide, particulate matter and other dangerous anthropogenic substances. GHG emissions harm the atmosphere, worsen the air quality and devastate the environment (McDonnel, Ferreira, & Convery, 2008; Pridmore & Miola 2011; Shaeen & Lipman, 2007). In addition, the pollution portends serious health hazards such as lung and respiratory diseases and cancer for the people (LAMATA, 2013; RAND Research Brief, 2008). This results in illness, loss of man hours and productivity and death. The high incidence of health hazard usually results in high medical bills incurred by governments (Segal, 1999), especially on the mainly majority poor, whose medical bills are heavily subsidized to be affordable.

It is therefore, imperative for policy-makers in developed and developing countries alike, to introduce measures to increase the attractiveness of PT and curb the growing stocks of private vehicles (Aminu & Olayinka, 2014b). A recent study noted that the popular means of PT in developed countries are train, buses, tubes, taxis and ferry (Aminu, 2015). In Nigeria, travelling by PT is only popular among the people in the lower rung of the ladder in the society (Basorun & Rotowa, 2012). There is need to make PT attractive to other categories of commuters, especially vehicle owners in Lagos and other major cities in Nigeria.

The Lagos State Government took a bold and laudable step in 2008 and introduced BRT in the Lagos metropolis (LAMATA, 2009; Moberola, 2009; World Bank, 2012). BRT is a transport option that uses dedicated, interference free segregated lanes to achieve fast and reliable journey (LAMATA, 2016). The scheme in Lagos is known as Lagos BRT and it is the first of its kind in Africa (Mobereola, 2009) to serve a large proportion of Lagos population (estimated to be over 17 million people)

living in the urban and sub-urban areas in the state. With this population, Lagos satisfies the status of a megacity, which is defined by the United Nations (UN, 2008) as a city with at least 10 million inhabitants. With this initiative, Lagos State has joined the league of countries that have implemented a BRT system of transportation in their cities.

An on-line source estimated that BRT has been implemented in 207 cities with over 5, 427 km length of roads and moving 34, 133, 647 passengers daily (BRT Data, 2016). Some of these cities are Bogota in Columbia, Curitiba in Brazil, Los Angeles, New York, Boston, Miami and Orlando in the U.S., Manchester in the U.K., and cities in China, Pakistan, India, South Africa, Mexico, Indonesia and North Korea (BRT Data, 2016). In fact, more than 10 cities in China have implemented the BRT system; some of these cities include Beijing, Xiamen, Jinan, Guangzhou, and so on (Cervero, 2013). What is common to all these and other cities that have implemented the BRT system of PT is large and growing populations with traffic congestion and other externalities (Aminu, 2016).

Lagos state has a huge population. This has resulted in a high level of motorization, with increase in the ownership of personal vehicles. This trend is made worsened by what the World Bank (2012) has described as a chaotic, unreliable and uncoordinated PT system in the state. Unfortunately, this has forced most vehicles owners to put their vehicles on the roads daily and encouraged non-vehicles owners to plan purchasing their own vehicles. The State Government, in collaboration with the World Bank, established Lagos Urban Transport Project (LUTP) to create a safe, reliable and integrated mass transit system. The result was the introduction of BRT in the state on March 17, 2008 (World Bank, 2012).

No single study, to the best of knowledge of the researchers, has linked transport externalities to ridership of BRT in Nigeria. This is understandable because an organized PT system like BRT is a recent phenomenon in the country. This paper fills this gap in the literature and contributes to the knowledge of environmental benefits of BRT in Nigeria. The major objective of the paper is to investigate whether or not the decision to ride BRT is related to the desire of commuters to reduce the adverse effects associated with excessive use of a private mode of transportation. Next section reviews related studies; section two presents the methods used to obtain and analyze data; section four presents results and discusses findings; and section five concludes the paper.

## LITERATURE REVIEW

### Conceptualization of PT and BRT

PT is all modes of transportation available to the public irrespective of ownership (White, 2002). PT provides mobility to those who cannot or prefer not to drive, including access to jobs, education, and medical services (Ferris, 2011). It plays a key role in moving people, as well as sustaining economic activity (Transit Cooperative Research Program, TCRP, 2011). As a shared mode, it moves from few passengers (taxis) to large passengers (mass transit and railway) across a wide range of socio-economic strata (Aminu & Olayinka, 2014a). PT modes include buses and coaches, taxes and private hire vehicles, tramways and light rail and urban heavy rail (Balcombe et al., 2004). Therefore, BRT is the most efficient and effective mode of transport.

BRT falls into a category of buses and has been defined in different ways. Transportation Research Board (TRP, 2003) defined BRT as a system that includes bus services that are, at a minimum, faster than traditional conventional bus service and that, at a maximum, includes grade separated bus operations. Wright (2005) provided a longer definition that incorporates all the important characteristics of BRT systems. He defined it as a high-quality bus-based transit system that delivers fast, comfortable and cost-effective urban mobility and through the provision of segregated right-of-way infrastructure, rapid and frequent operations and excellence in marketing and customer services. LAMATA provided a simple

definition as a transport option, which relies on the use of dedicated interference free segregated lanes to guarantee fast and reliable bus travel (LAMATA, 2016).

These definitions indicate that the attractiveness of BRT is the priority accorded it on the highways over other travel options, such as the regular PT and personal vehicles, through a dedicated and interference free and segregated lane (Aminu, 2015). Generally, BRT systems are characterized by guideway (segregated bus lanes and express routes), bus terminals and stations, pre-boarding automated fare collection, park-and-ride facilities, high occupancy buses, operating speed, route coverage, real-time passenger information systems, high frequency and customer services (Currie & Delbosc, 2010; Galicia, Cheu, Machemehl, & Liu, 2009; LAMATA, 2016; TRP, 2003; Wright, 2005). However, it is not necessary for all BRT systems to possess all these characteristics before they are qualified as BRT (Galicia et al., 2009). Lagos BRT "is not of the highest specification like the TransMilenio in Bogota or the Brisbane South East Subway both of which cost $6 million per kilometre" (Mobereola, 2009, p. 1).

Use of BRT, in major cities worldwide and as a viable alternative to a private mode, is increasing due to its rail-like technology and operations, which integrate high service levels, segregated right of way, station-like platforms, high quality amenities and intelligent transport systems (Currie & Delbosc, 2010); its advantages over the slow and inefficient conventional bus system and fast but expensive light rail (Galicia et al., 2009; Satiennam, Fukuda, & Oshima, 2006); and its cost-effectiveness over the rail-based PT systems (Imam & Jamrah, 2012; Vincent & Jerram, 2006). BRT has been implemented in 207 cities over 5, 427 km length of roads and moving 34, 133, 647 passengers daily (BRT Data, 2016). It was introduced in Lagos on March 17, 2008 over 22.5 km length of roads (LAMATA, 2009, 2013, 2016).

**An overview of Lagos BRT system**

The Lagos State Government, in 2008, introduced BRT in the state to make PT attractive and change the face of road transportation in the state. According to Lagos State Public-Private Partnership Office (PPPO, 2010), the Lagos State Government in collaboration with the World Bank initiated the Lagos Urban Transport Project (LUTP), to create an efficient and effective integrated inter-modal mass transit system in the state. To achieve this objective, the Lagos Metropolitan Area Transport Authority (LAMATA) was established vide Law No. 3, 2002 to coordinate the transport policies and activities of all transport related agencies. PPPO identified integrated inter-modal mass transit system as comprising ferry services, aviation services, rail mass transit and BRT (PPPO, 2010).

BRT was introduced to improve PT system in the state (Bakare, 2016). Lagos BRT, the first of its kind in Africa and the first organized and efficient PT system in Nigeria, was launched on March 17, 2008 (LAMATA, 2009; Mobereola, 2009; World Bank, 2012). Johannesburg and Cape Town in South Africa are the two other cities in Africa where a BRT system has been implemented (Carrigan, King, Velasquez, Raifman, & Duduta, 2014). The bus transport system in Lagos was established to provide a clean, affordable and reliable mode of commuting to commuters in Lagos metropolis. It is a type of BRT that does not have the advanced features of the TransMilenio in Bogota or the Brisbane South East Subway in Australia both of which cost $6 million per kilometer (Mobereola, 2009). There is no doubt that the Lagos BRT features reflect the state of the Nigeria's development and it is expected that additional features would be added as the country is growing on a development ladder.

The first phase of the Lagos BRT scheme was implemented on 22.5 km road network from Mile 12 to CMS on the Island. The scheme relied on 220 high occupancy buses to move passengers along the corridor (LAMATA, 2009). Between 2008 and 2013, BRT buses had moved over 400 million passengers on this corridor (LAMATA, 2013). Following the success of the first phase and a growing public demand to replicate the new transportation model in other corridors in the state, the BRT

operation was proposed to be extended from Mile 12 to Ikorodu to meet the urgent needs of commuters on the corridor (LAMATA, 2012). The brand name of this new corridor development is BRT Classic as against the existing BRT Lite (LAMATA, 2012, 2016). The Mile 12 - Ikorodu BRT lane is about 13.5 km long with the BRT running in the middle of the road to avoid interference from other traffic (LAMATA, 2016). Over 400 air-conditioned buses were introduced on the Ikorodu-CMS corridors. The new buses provide an opportunity for passengers to pre-load their boarding tickets with the use of e-purse (Bakare, 2016).

The BRT system of PT has impacted the people of Lagos state positively and redefined the concept of PT in the state. According to LAMATA (2016), the BRT system has led to a reduction of 30 per cent in average transport fares and fare stability, 40 per cent in journey time and 35 per cent in average waiting time and a decline in exposure to robbery incidents in PT; patronage of BRT buses by groups such as children, car owners and the elderly hitherto not commuting in BRT; and creation of direct employment for over 1, 000 people and indirect jobs for over 500, 000 people. It is, therefore, not surprising that BRT has moved a significant number of passengers since it was introduced in 2008. For example, as at 2015 it had moved 260, 000 passengers daily from about 180, 000 passengers daily in 2013 (LAMATA, 2013).

A number of regulatory institutions oversee the smooth operations of BRT in the state. According to Mobereola (2009), LAMATA provides BRT infrastructures and regulates the operations of the buses; Lagos State Traffic Management Authority (LASTMA) protects the exclusive use of BRT infrastructures and manages traffic conflicts in the box junctions on the highways; and kick against indiscipline (KAI) regulates the behaviors of the members of the public, including the commuters, traders and hawkers in the terminals and stations.

**Transportation externalities**

Generally, road transportation generates adverse effects (externalities) in the society. These side effects have been described as externalities or external costs of transportation. According to Korzhenevych et al. (2014), externalities or external costs described the costs imposed on a society from the side effects of any activity. While most forms of transport have positive effects on the society, they also generate adverse effects. Road transport generates the most side effects on the society (Korzhenevych et al., 2014). In particular, heavy reliance on personal vehicles, as a mode of transportation, causes severe externalities (Bel & Holst, 2015; Egeolu, 2014; Energy Information Administration, EIA, 2013; Federal Transit Administration, FTA, 2013; Odufuwa, 2011). Some of these externalities are reviewed below

*Personal vehicles cause congestion:* High use of personal vehicles in urban and sub-urban areas in major cities creates traffic congestion (FTA, 2013; Hidson & Muller, 2003; Minett & Pearce, 2011; Mobereola, 2009; Okanlawon, 2007). Hidson and Muller indicated that urban areas in Europe are affected heavily by congestion and nuisances caused by the excessive use of private vehicles. Similarly, FTA reported that poor air quality is associated with traffic congestion in urban and sub-urban areas in the U.S., with many separate private vehicle trips, resulting in higher health risks for people. There are high costs - wasted time, excessive fuel consumption and rapid wear and tear of vehicles - associated with the urban congestion in Lagos state (Okanlawon, 2007). This suggests that traffic congestion has huge socio-economic burdens. For example, Gwilliam (2002) asserted that the costs of time wasted in traffic congestion in several countries are about 1 to 3% of each country's GDP (cited in Maciel, Rosa, Correa, & Maruyama, 2014).

*Personal vehicles are a major consumer of petrol:* Transportation sector is the world's major consumer of petroleum products accounting for 58 per cent of total final consumption in 2004 (International Energy Administration, IEA, 2008), 52 per cent in Iran in 2005 (Mazraati, 2007), more than 75 per cent in U.S. in 2006 (Department of Energy, DOE, 2007), falling to 72 per cent in 2012 (EIA, 2013) and more than 75 per cent in Nigeria (Jaja, 2010). Jaja estimated the fuel consumption of

the 36 states in the country between 1971 and 2005 and reported that consumption in Lagos State grew from a low level of 122, 724 liters in 1971 to 1,852,267 liters in 2005, representing an increase of 1,409 per cent. He noted that the state consumed a total of 24,200,352 liters for the entire 31 years duration, representing 25 per cent of the total consumption in the country. The rising fuel consumption in the state is due to a growing fleet of vehicles. For example, Lagos State Government (2013) indicated that 1,303,066 new vehicles were registered in the state between 1995 and 2010.

*Personal vehicles emit more greenhouse gases (GHGs):* In addition, transportation emits carbon-dioxide ($CO_2$) and other GHGs. Transportation is a major emitter of $CO_2$ and other GHG emissions, contributing about 23 per cent of total global anthropogenic emissions (IEA, 2009), accounting for 20 per cent of $CO_2$ emissions in Japan (Kishi & Satoh, 2005), for 20 to 29 per cent in U.S. (FTA, 2013), 25 per cent each in Canada and U.K. (Basso & Oum, 2007), about 28 per cent in European Union (Hidson & Muller, 2003) and about 19 per cent in Nigeria (Knoema, 2016). Passenger cars and light duty trucks are the leading emitters of $CO_2$ (Bel & Holst, 2015; Vincent & Jerram, 2006; Wright, 2005). Sadly, the global transportation emissions have been projected to increase by 50 per cent by 2030 (IEA, 2009), with more damaging effects on the environment. This is as a result of the growing stocks and usage of personal vehicles (Sikirulahi & Salami, 2013; Wright, 2005).

*GHG emissions from personal vehicles cause health hazard to the people:* GHG emissions from personal vehicles have an adverse effect on the health and quality of life of people living in urban and sub-urban areas (Hidson & Muller, 2003; Hook, Fjellstroom, & Diaz, 2006; Mobereola, 2009; Wright & Fulton, 2005). Hidson and Muller indicated that urban areas in Europe are affected heavily by congestion and nuisances caused by the excessive use of private vehicles. Wright and Fulton pointed out that emissions from vehicle are the major contributor to the urban poor air quality and portend direct and severe health and environmental problems. They identified emission-related health hazards as respiratory illness, cardiovascular illness and cancer. Hook et al., lamented that increasingly deteriorating traffic congestion and air pollution are clear obstacles to healthy living and major urban cities and sustained economic growth in China. Mobereola attributed the worsening traffic congestion in Lagos to a limited road network and high rate of car ownership, fuelled by low petrol price and unregulated importation of fairly used vehicles. Finally, Egeolu (2014) noted that traffic congestion affects the life of people, causing acute stress, hypertension and other ailments. Therefore, there is consensus about the health hazards of emissions from automobiles.

**Transportation externalities reduction and ridership of BRT**

McDonnell, Ferreeira, and Convery (2008) posited that BRT aims at increasing the attractiveness of bus transport vis-á-vis other modes and has increasingly been used by transport policy-makers to address the external costs associated with the excessive transport demand. Therefore, drivers who are concerned about these externalities are likely to consider riding on BRT.

**Traffic congestion reduction and ridership of BRT**

PT, including BRT can attract motorists and take away several personal vehicles off the road in most urban areas, thus reducing traffic congestion (McDonnell et al., 2008; Odufuwa, 2011; Vincent, 2004). Vincent asserted that BRT has a strong potential to reduce congestion and improve air quality in U.S. McDonnell et al. suggested that BRT is aimed at increasing the attractiveness of bus transport vis-á-vis other modes and has increasingly been used by transport policy-makers to address the external costs associated with excessive transport demand such as congestion and time delays. Also, a BRT system was introduced by the Lagos State Government to motivate people towards the use of PT, thus reducing the number of private automobile and traffic congestion (Odufuwa, 2011). Prior to the reconstruction of the Ikorodu Road and introduction of BRT

on the corridor, commuters used to spend long hours on the corridor in one of the worst traffic congestion in the state. Carrigan et al. (2014) regretted that Metrobus has not been able to address the problem of congestion in the city of Mexico, because it covers only half of the urban areas.

Previous studies have validated the impact of a BRT system of PT on traffic congestion reduction. Adebambo and Adebayo (2009) found that BRT is a congestion-reducing transport option in Lagos Metropolis. The users' opinions about the BRT system in Lagos state showed that BRT has reduced riders' journey time along the corridors by 40 per cent, thus reducing congestion (LAMATA, 2016). From the foregoing, we hypothesize that:
*$H_1$: Motorists' desire to mitigate traffic congestion in Lagos metropolis makes them to commute in BRT.*

**Petrol consumption reduction and ridership of BRT**

Ridership of PT, including BRT can reduce the amount of fuel consumed by discouraging separate vehicle trips (Galicia et al., 2009; Hosssain & Kennedy, 2008; Litman, 2012; Maciel et al., 2012). For example, Litman compared the energy efficiency of bus and rail modes of PT with private passenger cars and noted that a bus with seven passengers is almost twice as energy efficient as an average automobile, and a bus with 50 passengers is about 10 times as energy efficient. Hossain and Kennedy claimed that increased modal shift in favor of PT can result in fewer cars utilizing the same road space. Galicia et al. attributed the increasing ridership in the U.S. and other cities to its faster journey and reduced travel time, thus creating an eco-friendly public transport system.

There is a body of evidence on the impacts of BRT on gasoline savings. Hossain and Kennedy (2008) found that BRT provides significant energy savings in Bangladesh in conventional bus lanes and full-scale BRT implementation, with the greatest savings achieved when locating the BRT in a newly constructed lane. The results of a study in 15 cities in Europe also indicated that BRT systems in these cities provide significant energy savings compared to commuting in automobiles (Imam & Jamrah, 2012). Maciel et al. (2012) estimated that PT policy that encourages Brazilians to use BRT, walk and cycle will save more than 35 million tons of energy consumption in Brazil by 2020. Aminu (2014) found that commuting in BRT in Lagos state, Nigeria significantly and positively correlates with gasoline savings. Conversely, Aaker and Bagozzi (n.d.) found that a rapid rail system and not a BRT system is more significant in reducing fuel consumption in the states of California and Los Angeles. Therefore, we hypothesize that:
*$H_2$: Motorists' desire to reduce gasoline consumption in Lagos metropolis makes them to commute in BRT.*

**Transportation emissions reduction and ridership of BRT**

"Passenger cars and light duty trucks are the most significant source of transportation emissions" (Vincent & Jerram, 2006, p. 220). Fukuda and Oshima (2006) suggested a modal shift from a private mode to a public mode of transport to reduce the impact of emissions on the environment, noting that emissions from the public mode is much lower than those of private mode. Hidson and Muller (2003) observed that urban PT is the most efficient transportation mode, creating a sustainable urban environment and attracting more riders. In Bogota, it was projected that implementation of BRT would reduce GHG by approximately 14.6 million metric tons of $CO_2$ equivalent in the transport sector (Wright, 2005). Similarly, FTA (2013) highlighted a number of environmental sustainable roles of PT as including air quality improvement, GHG abatement, compact development and travel demand reduction and energy savings. LAMATA (2014) stated that the BRT project in Lagos state has helped reduced dangerous pollutions along the corridors.

Studies have empirically validated the impacts of BRT systems on emissions mitigation. Instituto Nacional de Ecoloia (2008) estimated that emissions abatement from ridership of Metrobus in the city of Mexico will, between 2005 and 2015, reduce on

average, 144 tons of total hydrocarbons, 690 tons of oxides of nitrogen, 2.8 tons of fine particulate matter, and 1.3 tons of sulfur dioxide annually. Imam and Jamrah's (2012) study found that BRT systems in the 15 cities in Europe considerably reduced emissions in the cities compared to emissions from passenger cars. Marciel et al. (2012) found that riding in BRT, walking and cycling in Brazil can prevent 4, 000 tons of local pollution emissions and 37, 500 tons of GHG emissions by 2020 in the country. Baghini, Ismail, Hafezi, Seifabad, and Almansob (2014) found that a BRT system in Malaysia offers the greatest potential for GHG mitigation because of its lower $CO_2$ emissions per passenger mile compared to automobiles' emissions. Finally, results of a study by Bel and Holst (2015) in Mexico showed that BRT significantly reduced the emissions of Carbon dioxide, CO2, Nitrogen dioxide, $NO_x$, Particulate Matter, $PM_{2.5}$ and Particulate Matter $PM_{10}$. From the foregoing, we propose that:

*$H_3$: Motorists' desire to abate transportation emissions in Lagos metropolis makes them to commute in BRT.*

**Health hazards and ridership of BRT**

The high emissions resulting from excessive use of automobiles portend serious health hazards such as lung and respiratory diseases and cancer for the people (LAMATA, 2013; RAND Research Brief, 2008). This results in illness, loss of man hours and productivity and death (Segal, 1999). Onifade, Oladejo and Oyedeji (2010) equated transportation to the blood running through the vein of human body and stated that efficiency of transportation in moving people, goods and services around determine the quality of life of the people in the society. Levinson and Rutherford (2003) noted that BRT has a good prospect of substantially improving urban transit access, mobility and quality of life. Instituto Nacional de Ecoloia (2008) stressed that an effective control of vehicular pollution reduces population mortality and morbidity; improves visibility; reduces damages to crops, vegetation, ecosystems, buildings, and materials; and reduces pollutants contributing to climate change.

Instituto Nacional de Ecoloia (2008) Instituto Nacional de Ecoloia (2008) estimated that emissions abatement from ridership of Metrobus in the city of Mexico will, between 2005 and 2015, save an average of 6100 work loss days, 660 restricted activity days, 12 new cases of chronic bronchitis, and three deaths annually. Adebambo and Adebayo's (2009) findings suggested that BRT, as a congestion-reducing transport option in Lagos Metropolis, has a significant improvement on the quality of life of riders, as well as enhancing their accessibility. From the foregoing, we state that:

*$H_4$: Motorists' desire to reduce the health hazards associated with personal vehicles in Lagos metropolis make them to commute in BRT.*

**METHODS**

**The study area**

The study was conducted in Lagos State, South West Nigeria and the commercial nerve center and industrial base of the country. It has an estimated population of over 17 million. Though, Lagos state is the smallest state in Nigeria, it is the most populous; it is an economic hub of the country; and home to 45 per cent of the nation's workforce (Bakare, 2016). It is a mega city (UN, 2008) with a chaotic, unorganized and unreliable transportation system (World Bank, 2012).

**Research design, population and sampling**

We used a survey design. The target population consisted of all vehicle owners-turned BRT passengers along the Ikorodu-CMS corridor in the state, with a minimum of West African Examination Council (WAEC) or its equivalent qualification. A total of 1, 000 copies of questionnaire were administered to the sample inside the BRT with the help of the research assistants. A total of 926 copies of the questionnaire were found usable, representing an impressive 93% success rate. The huge retrieval rate was due to the fact that the participants were caught in a passive mood while commuting to their various destinations.

They were also properly sensitized by the researchers and two of their supervisors with the aid of megaphones, while on the queue in the terminals.

**Research instrument**

The study employed two instruments of data collection: structured questionnaire and observation to collect the necessary data. The questionnaire titled: "*Transportation externalities reduction and ridership of bus rapid transit in Lagos metropolis"* was developed by the researchers based on the research objectives and review of the literature. it was used to elicit the opinions of car owners-turned BRT commuters on the five research constructs. It was administered to the respondents inside the buses along the BRT corridors. The questionnaire had seven sections. Sections A to E of the scale has 24 items measured on a 4-Likert Scale, which includes: Strongly Agree (SA), Agree (A); Disagree (D); and Strongly Disagree (SD) on a scale of four, with SA representing 4 and SD 1. Section A - ridership of BRT buses by the respondents (outcome variable); while sections B to E are predictor variables. Section B - traffic congestion mitigation attribute of BRT; section C - gasoline consumption reduction attribute of BRT; section D - transportation emissions mitigation attribute of BRT; section E - health benefit attribute of BRT; section F - respondents' usage of personal vehicles; and finally, section G - respondents demographic data. The traditional passive moods of the commuters and their short period of stay in the buses demanded that the questionnaire was short with viewer number of items. This was to make the questionnaire easier to complete and elicit greater participation of the respondents.

There were filtering questions in the questionnaire to identify the right target population of car owners, who now ride in BRT. Any commuter who was neither a car owner nor possessing a minimum of WAEC or its equivalent qualification was not eligible to participate in the study.

Observation was used to collect data through a non-questioning mean. It was used to monitor the speed, frequency and stops of the buses along the bus corridors; interference with the buses by other road users (e.g. personal vehicles, commercial vehicles, commercial motor cycles, livestock and pedestrians) in the dedicated BRT lanes; conducts and courtesy of the drivers; conducts and courtesy of the ticketing officers; comfort and conducts of passengers in the terminal and inside the buses; passengers' waiting time in buying tickets and in boarding buses.

**Data analysis**

Data were analyzed using SPSS statistical software, version 20. Based on the data obtained from a pilot study, the validity and reliability of the instrument were determined. The research instrument was subjected to a content validity to ensure that all the items in the scale are good measures of the study's constructs. A content validity is established by ascertaining that the items in the instrument measure all the dimensions of a given construct (Carmines & Zeller, 1991). The instrument was given to senior colleagues within and outside the Polytechnic and some senior management staff of LAMATA for validation. Many of them found most of the items measuring each of the constructs essential. Minor corrections to the questionnaire were made to reflect their suggestions and comments.

A reliability test was also carried out to establish the reliability of the instrument. Cronbach's Alpha was used to measure the internal consistency of the research instrument. Cronbach's Alpha reliability co-efficient normally ranges between 0 and 1 with higher values indicating higher reliability among the indicators (Cronbach, 1951). This means that the closer Cronbach's alpha co-efficient is to 1.0 the greater the internal consistency of the items in the scale (Aminu, 2013). The research instrument was pretested on a sample size of 186 passengers of Bus Franchise Scheme (BFS), an alternative to BRT, on Ikotun-Iyana-Ipaja-Ikeja corridors. Multiple Regression was used to test the formulated hypotheses, processed on SPSS version 20.

**Table 1: Reliability of the research instrument**

| Constructs | Number of Items | Cronbach's Alpha |
|---|---|---|
| Ridership of BRT by motorists (RBRT) | 4 | .839 |
| Traffic congestion mitigation (TCM) | 4 | .872 |
| Gasoline consumption reduction (GCR) | 5 | .926 |
| Transportation emissions abatement (TEA) | 5 | .895 |
| Health hazards reduction (HHR) | 6 | .907 |
| Overall coefficient Alpha | 24 | .929 |

Table 1 shows Cronbach's Alphas for all the five constructs measuring the internal consistency of the scale on reducing the externalities of transportation with a BRT system of PT in Lagos metropolis. The overall co-efficient Alpha for the scale was .929, which is greater than an acceptable threshold (Cronbach, 1951; Nunally, 1978) while coefficient alphas for each of the subscales are also very high: RBRT (.839), TCM (.872), GCR (.926), TEA (.895) and HHR (.907). These Alphas indicate that our instrument is reliable and can be replicated in the future by researchers within and outside the country.

**Research model**

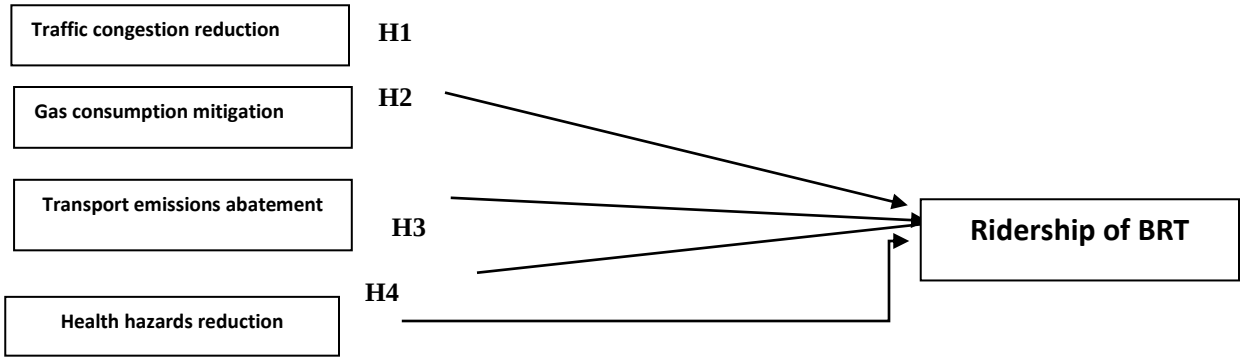


**Figure 1:** Research model based on literature review

## RESULTS AND DISCUSSION

### Results

*Descriptive statistics*

**Table 2: Demographic results**

| Variables | Frequency | Percentage | Variables | Frequency | Percentage |
|---|---|---|---|---|---|
| **Age**: | | | **Highest level of education**: | | |
| 21-30 years | 219 | 23.7% | O' Level | 108 | 11.7% |
| 31-40 years | 394 | 42.5% | ND/NCE/A' Level | 225 | 24.3% |
| 41-50 years | 222 | 24.0% | BA/BSc./HND | 426 | 46.0% |
| Above 50 years | 90 | 9.7% | MA/MSc/MBA | 157 | 17.0% |
| **Total** | 926 | 100.0% | PhD | 10 | 1.1% |
| | | | **Total** | 926 | 100.0 |
| **Gender**: | | | **Occupation**: | | |
| Male | 582 | 62.9% | Public sector employees | 225 | 24.3% |
| Female | 344 | 37.1% | Private sector employees | 317 | 34.2% |
| **Total** | 926 | 100.0% | Self-employed | 384 | 41.5% |
| | | | **Total** | 926 | 100.0% |
| **Marital status**: | | | **Monthly income**: | | |
| Single | 253 | 27.3% | Less than N100,000 | 407 | 44.0% |
| Married | 661 | 71.3% | N101,000 - 200,000 | 353 | 38.1% |
| Divorcee | 12 | 1.3% | N201,000 - 300,000 | 96 | 10.4% |
| **Total** | 926 | 100.0% | N301,000 - 400,000 | 31 | 3.3% |
| | | | N401,000 - 500,000 | 14 | 1.5% |
| | | | Above N500,000 | 25 | 2.7% |
| | | | **Total** | 926 | 100.0% |

**Source: Fieldwork, 2016.**

Table 2 shows the demographic distribution of the respondents. There are more male respondents, 582 (62.9%) than female respondents, 344 (37.1%) that participated in the survey. Majority of the respondents, 616 fall within the age bracket of 31-50 years, representing 66.5% of the entire population of the subjects. This indicates that majority of the participants are old enough to make a good judgement about their transport mode choice. An overwhelming majority of the respondents, constituting 71.4% are married compared to 253 respondents (27.3%) who are single. Interestingly, 426 respondents, constituting 46% have a minimum of B.Sc honors degree or its equivalent. The closest qualification frequency to this is respondents with a minimum of ND or its equivalent, which is 225 (24.3%). The high number of graduates commuting in BRT reflects the calibre of BRT passengers.

The occupation distribution of the respondents shows that all the three sectors are well represented, with self-employed respondents, 384 (41.5%) in the simple majority, followed by private employees, 317 (34.2%) and public sector employees, 225 (24.3%). This suggests that BRT is attractive to motorists across the three major occupations. Finally, monthly income distribution of the respondents shows that 407 respondents (44.0%) earn a monthly income less than N100, 000; 353 respondents (38.1%) earn monthly incomes of between N101, 000 and N200, 000; the rest respondents, 166 (17.9) earn from N201, 000 and above N500, 000. The analysis shows that majority of the respondents fall in the income bracket of less than N100, 000 per month. This suggests that majority of the participants in the study are marginal vehicles owners who do not

earn enough monthly income to maintain their vehicles regularly. It is convenient for this category of respondents to quickly switch to BRT, a more comfortable PT.

**Multiple regression model**

Multiple regression was used in this study to estimate the relationship between motorists' desires to reduce external costs associated with personal vehicles driving and their commuting in BRT. BRT is the dependent (outcome) variable, while TCM, GCR, TEA and HHR are the independent (predictor) variables. The Method=Enter approach was used in the SPSS, meaning that all the independent variables were entered into the regression equations at once. The output is shown in the tables 3 and 4 below:

**Table 3: Multiple regression model summary statistics, co-efficient of determination, and significance223**

| R | R Squared | Adjusted R Sq. | Std Error of the Estimate | Degree of Freedom | F | P-Value |
|---|---|---|---|---|---|---|
| .632 | .399 | .306 | 4.871 | 915 | 48.121 | .000 |

Table 3 above shows the model specification for the regression model, co-efficients of determination (R) and significance. The "R" shows the strength of the relationship between RBRT and TCM, GCR, TEA and HHR. The value of R = .632 indicates it is a good level of prediction. The co-efficient of determination ($R^2$) for the model is .399. This suggests that TCM, GCR, TEA and HHR in the model explains about 40% of the variability in RBRT. The remaining 60% is explained by factors not considered in model. Also, the *F*-ratio in the ANOVA table incorporated in table 3 indicates that (48.121, $p < 0.000$). This means that the independent variables (TCM, GCR, TEA and HHR) statistically significantly predict the dependent variable (RBRT) at the 95% confidence level.223

**Table 4: Co-efficients[a]**

| Model | | Unstandardised Co-efficients | | Standardised Co-efficients | T | Sig. | 95.0% Confidence Interval for B | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound |
| 1 | (Constant) | 18.209 | .470 | | 17.467 | .000 | 7.287 | 9.132 |
| | Traffic congestion mitigation (TCM) | .316 | .030 | .150 | 3.907 | .000 | .058 | .175 |
| | Petrol consumption reduction (PCR) | .232 | .029 | .045 | 1.117 | .000 | .089 | .024 |
| | Transport emissions abatement (TEA) | .223 | .025 | .029 | .715 | .000 | -.040 | .086 |
| | Health hazards reduction (HHR) | .170 | .016 | .261 | 2.736 | .000 | .121 | .219 |
| | a. Dependent Variable: Ridership of BRT (RBRT) | | | | | | | |

**Hypothesis testing**

In testing the four hypotheses formulated in the paper, we focused on the standardized beta (b) and t-test statistic's level of significance (Sig.) for each of the four independent variables in the co-efficients table 4 above. As a rule, where $p<.05$, we accept the hypotheses because they are statistically significant, otherwise we reject them.

**Hypothesis 1:** *Motorists' desire to mitigate traffic congestion in Lagos metropolis makes them to commute in BRT.*

TCM in the co-efficients table above is statistically significant (b = .150, p<.05). This indicates that $H_1$ is confirmed.

**Hypothesis 2:** *Motorists' desire to reduce gasoline consumption in Lagos metropolis makes them to commute in BRT.*

GCM in the co-efficients table 4 is statistically significant (b = .046, p<.05). This shows that $H_2$ is supported.

**Hypothesis 3:** *Motorists' desire to abate transport emissions in Lagos metropolis makes them to commute in BRT.*

TEA in the co-efficients table above is statistically significant (b = .029, p<.05). This shows that $H_3$ is found to be true.

**Hypothesis 4:** *Motorists' desire to reduce health hazards in Lagos metropolis makes them to commute in BRT.*

HHR in the co-efficients table 4 is statistically significant (b = .261, p<.05). Finally, hypothesis 4 is also confirmed.

## DISCUSSION

### Discussion of survey findings

This paper aims to investigate whether or not ridership of BRT by a growing number of motorists is related to their desires to reduce the externalities associated with the excessive use of personal vehicles in a cosmopolitan and mega city like Lagos. These externalities are traffic congestion, high gasoline consumption, transport emissions and health hazards to the people. The results of the study supported the four formulated hypotheses.

The first result indicates that motorists ride in BRT because they are interested in mitigating traffic congestion in Lagos metropolis. The findings of existing studies (Adebambo & Adebayo, 2009; LAMATA, 2016) have shown that BRT reduces traffic congestion in major cities bedeviled by congestion. This suggests that motorists who have switched to BRT did so because they recognize that continued making separate vehicle trips via a personal mode contributes to the perennial and seemingly intractable traffic congestion along the Ikorodu-CMS route. Lagos state, with a population of over 17 million people, has the worst traffic congestion in the country. The state government took the bull by the horn with the introduction of BRT, the first of its kind in Africa, in 2008 (LAMATA, 2009; World Bank 2012). The expectation is that as more bus corridors are opened and more motorists in the metropolis find BRT more attractive than driving their vehicles, they are most likely to park their vehicles and ride in BRT, with a significant impact on the smooth flow of traffic on Lagos highways, generally.

The second result shows that motorists' desires to reduce gasoline consumption in the metropolis make them to commute in BRT. Similar studies have found that BRT is more efficient, as a public mode of transport, in reducing fuel consumption (Aminu, 2014; Hossain & Kennedy, 2008; Imam & Jamrah, 2012; Maciel et al., 2012). Excessive fuel consumption constituted a fiscal burden to the successive Nigerian governments (Aminu & Olayinka, 2014a). Therefore, the finding indicates that majority of the motorists who considered their fuel consumption high, resulting from their personal vehicle-dependent lifestyle, have switched to BRT, a more fuel-efficient mode of transport, to save fuel. The result also suggests that more motorists in the metropolis will save fuel by commuting in BRT as the existing BRT lanes are extended.

The third result suggests that motorists' ridership of BRT is due to their quest to abate transport emissions in the metropolis. Existing research has validated the relationship between BRT and transport emissions abatement in cities facing the challenge of excessive use of personal mode of transport (Baghini et al., 2014; Bel & Holst, 2015; Imam & Jamrah, 2012; Instituto Nacional de Ecoloia, 2008; Marciel et al., 2012). Transportation is a major emitter of $CO_2$ and other GHG emissions, contributing about 23 per cent of total global anthropogenic emissions (IEA, 2009). In Nigeria, transportation emission is

about 19 per cent (Knoema, 2016). Passenger cars and light duty trucks are the leading emitters of $CO_2$ (Bel & Holst, 2015; Vincent & Jerram, 2006). As more bus corridors are opened in the Lagos metropolis and more drivers are attracted to ride in BRT, transport emissions in the metropolis will reduce significantly.

Finally, our result suggests that Motorists who are interested in reducing the health hazards associated with excessive driving and its attendant consequences and improve their quality of life choose to transit in BRT in the metropolis. The high emissions resulting from excessive use of automobiles portend serious health hazards such as lung and respiratory diseases and cancer for the people (LAMATA, 2013; RAND Research Brief, 2008). This results in illness, loss of man hours, productivity and death (Segal, 1999). Instituto Nacional de Ecoloia (2008) estimated that emissions abatement from ridership of Metrobus in the city of Mexico will save an average of 6100 work loss days, 660 restricted activity days, 12 new cases of chronic bronchitis, and three deaths annually. A study found that BRT has a significant improvement on the quality of life of riders in Lagos Metropolis (Adebambo & Adebayo, 2009). As more motorists become aware of the harmful effects of excessive driving and BRT's service becomes extensive in the metropolis in a couple of years, more motorists will switch BRT for commuting purposes. Inevitably, motorists would have their health and quality of life improved as they would not need to be behind wheels for a long period of time while commuting.

**Discussion of observational findings**

Data obtained by observing the activities of BRT showed that there were long queues of orderly passengers who wanted to board at each of the major terminals along the Ikorodu-CMS bus corridors both at the peak periods of morning (when people were going out) and in the evening (when they were returning home). This is an indication that the BRT service is widely accepted and patronized. However, the bus frequency was observed to be low resulting in passengers' long waiting times and which may affect the attractiveness of the buses to an important segment, motorists, if more buses are not made available to satisfy the commuting need of the enthusiastic and mammoth crowd. Adelaide North East Busway found that the frequency advantage of Busway stations in Adelaide, Australia made them attractive to car drivers (cited in Currie, 2006). LAMATA (2016) affirmed that by offering frequent services and avoiding traffic-related delays, BRT systems can guarantee a more reliable travel time.

At both Ikorodu and Agric terminals, ticketers were seen dispensing boarding pass (ticket) to passengers via Point of Sales (PoS) devices. Unlike queues of the passengers that were ready to board buses, the queues of those seeking to buy tickets were a bit disorderly. BRT officials were on ground to control the passengers on queues. A sad part of ticketing is exchange of words between ticketers and passengers over customers' money balance (popularly called 'change' in Nigeria), making some of the ticketers rude to the passengers. Because of the challenge of lack of 'change', ticketers preferred to dispense tickets to passengers who have the actual face value of the ticket for a particular route.

The two researchers rode on the buses throughout the period of data collection to observe the buses' speed and interference, if any. It was found that the buses' speeds had been regulated to ensure safe rides on the bus corridors. It was observed the drivers of the buses are professionals and maintained maximum concentration behind the wheels, avoiding unnecessary conversation with the passengers. Passengers, especially those that are seated are very comfortable, enjoying the air-conditioned and serene ambience of the buses. The major interference observed was the activities of the motorcycle ('okada') riders, who plied the dedicated lanes with impunity. Few yellow buses were also seen taking the lanes. Other categories of road users (personal vehicles, corporation fleet, taxis, etc) were seen avoiding the marked BRT lanes.

Importantly, operations of BRT and the reconstruction of the Ikorodu-Mile 12 road have significantly reduced the once perennial traffic logjams that had characterized the road. Our observations showed that the traffic that used to stretch from Mile 12 bus-stop to Agric bus-stop, on Ikorodu outskirt (about 16 km trip) now stretched from Mile 12 to Owode-Onirin and

sometimes to Owode-Elede (both are less than seven km), depending on the times of the day. Our observations further showed that BRT buses are not affected by the usual congestion that other road users often face because they mostly drive on dedicated lanes. This is the major characteristics of the BRT system of PT (Aminu, 2015). For example, studies are unanimous that BRT systems are characterized by guideway (segregated bus lanes and express routes) (Currie & Delbosc, 2010; Galicia et al., 2009; LAMATA, 2016; TRP, 2003; Wright, 2005). Inevitably, this has made BRT attractive to many commuters in the metropolis, including car owners, who previously commuted in a personal mode, which is seen to provide speed, comfort, convenience, security and privacy (Basso & Oum, 2007). These findings are remarkable because traffic congestion is the worst of transportation externalities, producing other externalities - high gasoline consumption, high emissions and deteriorating health of drivers and other road users - investigated in the paper. For example, Maciel et al. (2014) cited by Gwilliam estimated the costs of time wasted in traffic congestion in several countries to range from 1 to 3% of each country's GDP.

## CONCLUSION AND IMPLICATIONS OF THE FINDINGS

The major cities of the world are associated with a high level of motorization due to the preferences of individuals for a personal mode of transport instead of a public mode. This personal mode-dependent lifestyle of many vehicle owners produces external costs (adverse effects), which include traffic congestion, high gasoline consumption, excessive transport emissions and health hazards. The paper investigates whether the decision by motorists to reduce these externalities explain their ridership of BRT in the heavily populated Lagos metropolis. Our results supported all the four hypotheses of the paper, indicating that transportation externalities (traffic congestion, gasoline consumption, transport emissions) reduction and health improvement are the reasons vehicle owners choose to commute in BRT in the metropolis. We concluded that as more motorists become more environmentally responsible and seek reduction in these externalities, they will choose to ride in BRT in the metropolis.

Our regression model suggests that as more vehicle owners in the metropolis become more environmentally responsible and choose to reduce these externalities, ridership of BRT among this category of commuters will increase. However, the quality of the vehicle owners, in terms of their monthly earnings, who participated in the survey is of concern to the researchers. This is because our data indicate that 82 percent of the respondents earn a monthly income of N200, 000 or below, an income that may not be sufficient to cater for the monthly expenses of a family with four children. Therefore, this category of vehicle owners can be described as marginal vehicle owners, who will not hesitate to park their vehicles should their earnings be threatened by job loss or business downturn and/or by increase in the costs of living as is the case presently in the country.

Based on the findings of the paper, some policy and managerial implications are highlighted. Firstiy, in terms of policy, LAMATA should embark on regular enlightenment campaigns and advocacy programs to encourage environmental friendly behavior by the huge population of vehicle owners in the metropolis. This will increase their knowledge about their environmental responsibility and behavior. Studies have found a positive relationship between environmental knowledge, responsibility, attitude and pro-environmental behavior (Kim, Jeong, & Hwang, 2012; McMakin, Malone, & Lundgren, 2002). Secondiy, in terms of managerial implication, as the number of motorists who are more environmentally responsible

are expected to grow and switch to BRT for commuting purposes, there is urgent need by BRT management to allocate more buses on the corridors to improve the low frequency of buses along the corridors and reduce the current long queues and waiting times of passengers in all the terminals in the metropolis. High bus frequency is one of the features of a BRT system (Currie & Delbosc, 2010; Galicia et al., 2009). High frequency is necessary to attract and retain more vehicles drivers to ride in BRT. Levinson and Rutherford (2002) strongly believed that BRT should be rapid, suggesting that high frequency means less waiting. Shim, Rhee, Ahn and Chung (2006) stated that an improvement in the service level of mass transit would be effective in increasing the usage of PT.

Thirdly, the management should consider deploying highly aesthetic, long, high capacity, low-floor and multi-door buses on the existing and new corridors to make them more attractive to drivers. Levinson and Rutherford (2002) suggested that buses should be distinctively designed to attract more riders. They suggested that the buses should provide sufficient passenger capacity, multiple doors, and low-floors for easy passenger access. Vincent (2004) explained that the Los Angeles BRT, Metro Rapid, use modern 40-foot, low-floor, and compressed natural gas buses to move passengers around seven corridors in the city and this increased ridership. Finally, BRT management should target motor owners with high quality marketing and promotional programs that highlight the speed, comfort, security and safety of riding on BRT. In Bogota, Colombia, series of activities, including community and business meetings, advertisements and events, and three weeks free ride on TransMilenio were executed to promote ridership of BRT (Wright, 2005).

## FURTHER RESEARCH

There is no doubt that BRT is at the growth stage of product life cycle (PLC) in Lagos state with a prospect to attract more individuals who still prefer to drive their vehicles. Therefore, additional research is needed to broaden our knowledge in this current research area. One important area of further research is how to motivate wealthier vehicle drivers to ride in BRT and the implications of this for transport externalities reduction in the metropolis. Also, as Orile-Badagry road reconstruction is advancing in the metropolis, additional research is needed to survey the desire of motor owners along the corridors to commute in BRT.

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**ABOUT THE AUTHOR:**

Suraju Abiodun Aminu, PhD., Department of Marketing, Lagos State Polytechnic, Ikorodu, Lagos state, Nigeria

Olugbenga Ezekiel Pearse, Department of Marketing, Lagos State Polytechnic, Ikorodu, Lagos state, Nigeria