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TELECOMMUNICATION INFRASTRUCTURE CONDITION AND CONSUMERS' BRAND LOYALTY IN SMART CITIES: THE CASE OF METROPOLITAN LAGOS

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ABSTRACT*: Smart cities are compact in nature and largely driven by technology especially information communication technology (ICT). The availability of telecommunication service in a smart city is a 'conditio sine qua non' for efficient development of the city and the utilization of urban resources for optimal production with less stress. However, efficient telecommunication service depends on robust telecommunication infrastructure. This study examined the state of telecommunication infrastructure and the relationship between the condition of telecommunication infrastructure and telecommunication brand loyalty among global services mobile (GSM) consumers in Lagos State, Nigeria. Relevant data was gathered through the use of questionnaire, interviews and observations from four GSM telecommunication operators in Lagos State, Nigeria. This cross-sectional survey used multi-level sampling technique involving: (a) Non-Probability Purposive Sampling Technique to select respondents Station Managers, and Engineers from GSM service provider companies, and (b) Systematic Random Sampling Technique to select the service consumers (GSM users). Descriptive statistics of frequency count, mean, standard deviation, and ranked mean item score were used to obtain the availability and condition of telecommunication infrastructure, while Pearson Correlation Coefficient was used to test hypotheses of this study. This study concludes that telecommunication infrastructure condition positively correlates with GSM consumers brand loyalty, and recommends increased government funding for the provision and improvement of the state of public electricity and general security infrastructure in Lagos State and other states of Nigeria for cheaper telecommunication business operation costs in support of smart city aspirations.*

KEY WORDS: consumers' brand loyalty, metropolitan lagos, smart city, telecommunication infrastructure.

INTRODUCTION

Smart cities are compact and efficient with smart people, smart mobility, smart infrastructure and smart governance. A city is said to be smart when it employs information and communications technology (ICT) to increase efficiencies in various sectors of the urban economy at reduced cost resulting into higher living standards for the urban residents. In today's Internet of Things (IoT), smart infrastructure driven by modern Information and Communication Technology is the foundation for developing smart cities (Hu, 2019). Consequently, smart telecommunication infrastructure is the bedrock upon which every other smart urban component is built. However, building and maintaining robust telecommunication infrastructure in good condition in an urban environment such as Lagos with ever increasing population is both expensive and technically challenging. According to Hu (2019), there is a wide recognition of the fact that building "smart" technologies into an existing city — or developing a Smart Sustainable City from the ground up — is a complex undertaking and calls for improved cooperation and more integrated decision-making by a variety of stakeholders. However, according to Deloitte (2015), the reality of the urban dynamics in smart city environment underscores the increasing need for "smart" city solutions which are both efficient and sustainable on one hand and can on the other hand, generate economic prosperity and social wellbeing for the city dwellers.

Problem Statement, Objective, and Relevance of the Study

Efficient telecommunication service depends on robust telecommunication infrastructure (Ijewere, and Gbandi, 2012). Invariably, the condition of telecommunication infrastructure might correlate with the quality of ICTs services available to the service subscribers. According to Akinola (2007), paucity of public infrastructure, cause both individuals and business entities to go into private provision. Poor condition of telecommunication infrastructure is contrary to smart city expectations. Furthermore, it will also amount to a poorly coordinated smart city development effort for Lagos State to up-grade other areas of urban development of the "city state" without the telecommunication infrastructure being programmed to be ahead of the urban development or at worst to be on the same page with it.

Consequently, a good empirical understanding of the effects of the condition of telecommunication infrastructure on: service quality, complaints resolution time, stability of services, and network coverage is important in revealing telecommunication services consumers brand loyalty. The findings of this study will be critically important for telecommunication industry regulation, telecom infrastructure investment decisions and service providers' competitiveness in an urban economy. Information on the condition of telecommunication infrastructure in Lagos State and its linkages with: service quality, complaints resolution time, service provider ratings, performance awards, and telecommunication service consumers' brand loyalty is lacking in existing literature. The dearth of information in this vital success metrics for smart city aspiration in Lagos State is considered a critical gap in knowledge to be filled by this study.

Consequently, the objective of this study is to examine the relationships between telecommunication infrastructure condition and GSM brand loyalty in Lagos State, Nigeria. While the null hypothesis to be tested in this study is formulated from the objective as, **Null Hypothesis**

(H_o): There are no significant relationships between telecommunication infrastructure condition and GSM brand loyalty in Lagos State, Nigeria.

Nevertheless, this author is aware of the sub-optimal state of telecommunication service performance in Lagos State as well as in other states of Nigeria as Achumba, Ighomereho, and Akpor-Robaro (2013) confirmed that the telecommunication industry in most developing countries including Nigeria has not fully contributed to the economics of the countries. In response, this study is an attempt to bridge the perceived knowledge gap highlighted above. Therefore, the study examined the condition of telecommunication infrastructure and its relationship with the GSM consumers' brand loyalty in Lagos State, Nigeria and in the process identified the factors responsible for the present condition of telecommunication infrastructure in Lagos State, Nigeria which could be focused on for scalable industry performance improvement strategy in sync with smart city status. Improved telecommunication infrastructure in Lagos State will make for efficient telecommunication service delivery resulting into effective smart urban mobility, curbs: intra city urban travels, the associated environmental pollution, and greenhouse effect while elevating general urban efficiency and individual welfare at minimal stress. According to Alleman, et al. (2016), the vision of a smart sustainable city is one of a highly efficient "system of systems" built on the horizontal and vertical integration of city processes, making full use of the data generated by IoT enabled systems.

Conceptual Issues in the Role of Telecommunication Infrastructure in Smart Cities

Smart Cities are characterized by a number of factors including sustainability, economic development and a high quality of life. European Commission cited in Deloitte (2015) suggested that the factors that characterize smart cities can be achieved through a combination of: infrastructure (physical capital), human capital, social capital and/or Information and Communication Technologies (ICT) infrastructure. Consequently, the development of a smart city is neither an overnight affair nor a one-off activity. The US Office of Scientific and Technical Information recognized the continuous concerted efforts and activities that drive smart cities when it asserted that a smart city is one that monitors and integrates conditions of all of its critical infrastructure including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings in a way that can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens.

Speed is of essence in smart cities. To ensure speedy handling of things in smart cities, scalable solutions driven by ICTs are employed in most urban activities and processes in order to increase urban efficiencies as well as to elevate the general quality of urban life. However, the much-desired speed in performing activities in the urban space may largely dependent on the condition of the telecommunication infrastructure which supports telecommunication services of the service providers via co-location (use of the same telecommunication infrastructure e.g., use of one mast by more than one service provider) concept in the hosting of service providers facilities e.g., satellite dishes, transmitters, decoders etc.

The installation, and effective operation of telecommunication infrastructure is a highly technical assignment. Moreover, ICT technology is dynamic and highly innovative. International Telecommunications Union (ITU, 2016) noted that interest in Smart Cities has triggered plenty of theoretical and technology-led discussions, but that enough progress has not been made in implementing the related initiatives. In addition, ITU also observed that technology is not well-understood across city sectors thereby undermining the optimal functioning of the installed capacity of urban infrastructure in many countries especially in developing countries including Nigeria.

Lagos State is continuously making huge investments in the upgrading of urban infrastructure in line with the pursuit of Smart Lagos City aspirations. All the new state of art infrastructure driven by modern high-tech are expected to latch on ICTs in some ways for efficient functioning. In smart cities, residents rely largely on the use of ICT services to network in many areas for improved productivity and less stressful lives. Physical mobility is usually made smart and less frequent while virtual smart mobility using ICTs is the in fashionable culture. Consequently, availability of telecommunication service in a smart city is a 'conditio sine qua non' for efficient development of the smart city and the utilization of urban resources for optimal production with less stress.

However, a survey of existing literature has revealed challenges to efficient telecommunication infrastructure in developing countries in the areas of human resources, availability of public infrastructure, industry practices, public regulation, and fiscal policies. It is important to find out the extent to which each of the highlighted issues feature in Nigerian telecommunication industry particularly in Lagos State, Nigeria.

3.0 Over view of Telecommunication Infrastructure and Contemporary Issues in Nigeria

Telephone and internet access in Nigeria typically go through mobile networks, which offer relatively fast and reliable connection. Mobile services have spread much more rapidly than land ones in Nigeria. Cellular voice and text services have experienced a steady rise from the late 1990s, and were joined by mobile internet capabilities from the beginning of the 21st century. As at today, most internet connections are done via mobile networks, and the Mobile operators in Lagos and other states of Nigeria are presented in Table 1.

Table 1: Showing the Distribution of GSM Subscription across Networks in Nigeria

Ranking	Network	Number of Subscriptions (Millions)
1	South Africa's MTN	45
2	Glo mobile	24.45
3	Airtel	17.2
4	Etisalat,	8.6

Source: Nigerian Telecommunications Commission (2020).

Table 1 shows that South African MTN enjoys the largest market share in GSM subscription in Nigeria, as it leads the industry with 45million subscribers. MTN is distantly followed by Glo

mobile with less than 25million subscription. Airtel ranks the third behind Glo mobile with a little over 17million subscriptions, while Etisalat occupies the last position with 8.6million customers.

Perhaps, GSM customers' choice of network subscription may unknowingly correlate with telecommunication infrastructure condition, and technology in use. However, secondary data from existing literature reveals the technology typologies available in Nigerian telecommunication industry in Table 2 to consist of GSM, CDMA, Fixed Wireless and Wired Connections, Voice Over Internet Protocol (VoIP).

Table 2: Shows the Distribution of Telephone Technologies in Nigeria

Ranking	Network	Market Share (%)
1	Global Systems Mobile (GSM)	99.7
2	CDMA Connections	0.1
2	Fixed Wireless and Wired Connections	0.1
2	Voice Over Internet Protocol (VoIP)	01

Source: Nigerian Telecommunications Commission (2019).

A cursory look at Table 2 reveals the prominence of GSM services among the four technology types in use in telecommunications industry in Nigeria. It implies that GSM technology is prevalent among the network providers, and so an examination of the condition of the GSM telecommunications facilities used by the various service providers in Lagos State is quite informative and useful for ensuring service efficiency and industry growth.

Furthermore, the Nigeria telecommunications industry statistics 2011 confirmed that all GSM operators in Nigeria operate on the same technology as can be seen on Table 3.

Table 3: Showing the Distribution of Technology and Ownership GSM firms in Nigeria

Operator	Technology	Subscribers (Millions)	Ownership
MTN	GSM, HSDPA	40.54	MTN SOUTH AFRICA (76%)
Glo Mobile	GSM, HSDPA	19.488	Globacom
Airtel	GSM, HSDPA	15.969	Bharti Airtel (65.7%)
Etisalat	GSM, HSDPA	7.835	Etisalat, Mubadala, Nigerian Investors

Source: Nigerian Communications Commission (NCC, 2011).

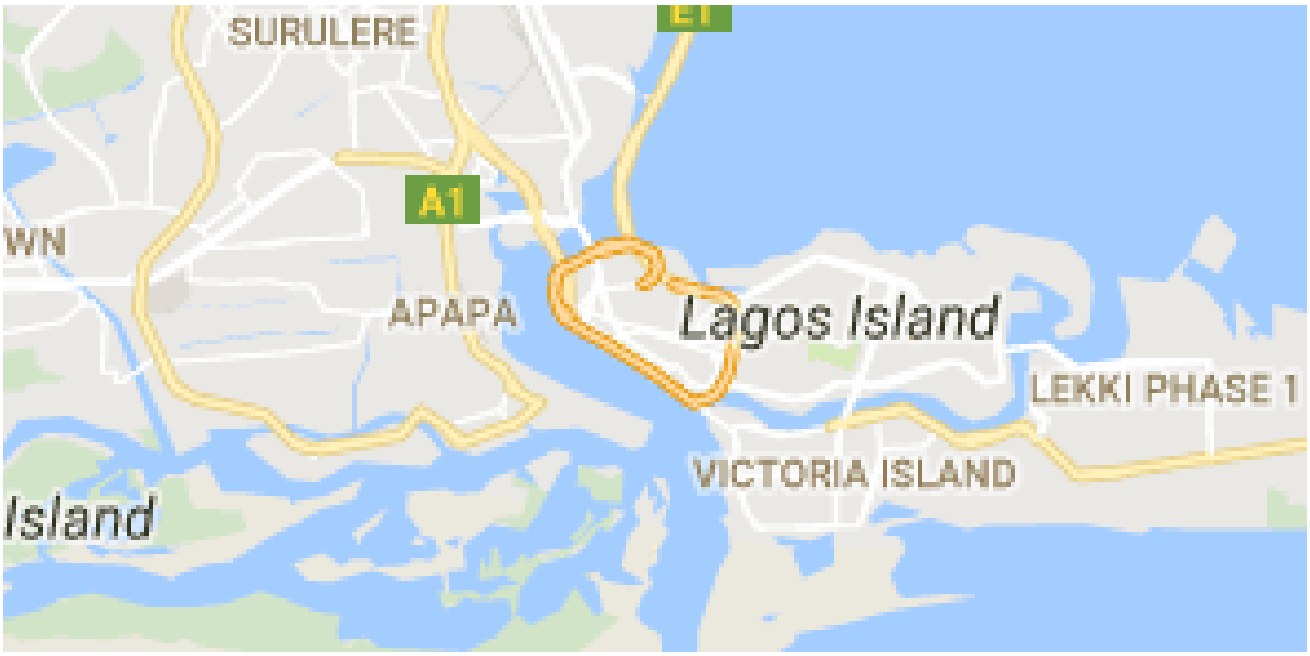
The data in Table 3 reveals that GSM (Global Systems Mobile), and HSDPA (Provide full meaning) are the two technology types used by all the service providers in Nigeria regardless of the ownership and market size.

METHODOLOGY

This study adopted a cross-sectional survey approach taking a single shot in data collection from the respondents. Therefore, this research is exploratory in nature and used multi-level sampling technique in which on the one hand, non-probability sampling (purposive sampling technique) was used to select respondents (Station Managers, and Engineers) from GSM service provider companies by snow-balling from one respondent to another in order to collect and analyse information on telecommunication infrastructure condition. While on the other hand, systematic random sampling technique was used to select the service consumers (GSM users) sampled in the survey to elicit response to structured questions and analyse the information gathered about consumers' brand loyalty in smart cities in Lagos.

Lagos State as the setting of the study is a coastline land mass with southern boundary lying along 180-kilometer distance on Atlantic shorelines in the south western part of Nigeria. It shares northern and eastern boundaries with Ogun State. On the western side, Lagos state shares a common boundary with Republic of Benin. Lagos became the capital of Nigeria in 1914, it continued to play this administrative function until December 12, 1991 when it lost the position to Abuja Federal Capital Territory.

Lagos State is the second most populous state in Nigeria; with a population figure of 9,013,5341 (a figure generally believed to be unrealistic as it grossly under estimated the state population) representing 6.44% of Nigeria's total population and a gender distribution of 51.9% males and 48.1% females (National Population Census, 2006). However, a parallel census carried out by Lagos State government around 2006, put the population of the state then at 12 million. The metropolitan Lagos area (which covers about 37% of the Lagos land mass) hosts about 85% of the population, resulting in an average population density of 20,000 persons per sq km. Population growth is estimated at about 275,000 persons per annum (Roland Igbinoba Real Foundation for Housing and Urban Development, 2009). Lagos State was chosen for this study because, it is the centre of commercial activity in Nigeria (Apulu, Latham & Moreton 2011), and has the highest concentration of GSM subscribers in Nigeria (NCC 2011).



Source: Figure 1 Map Data "A" @ 2018 Goggle Earth. Showing the Locations of Lagos Island, Victoria Island, Lekki, Apapa, Surulere etc. in Lagos State.

Figure 1 shows the geographical locations of: Lagos Island, Victoria Island, Lekki, Apapa, and Surulere, while the location of Ikeja is shown in Figure 2 below.

Table 4: Showing Sample Size Distribution in the Study Location

S/N	Location	Population GSM Subscribers	Sample Drawn
1	Lagos Island	127,620	180
2	Victoria Island	1,875	120
3	Lekki Phases	240763	170
4	Apapa	130596	85
5	Surulere	415,500	90
6	Ikeja	187917	200
	Total	1, 104271	**845**

Source: National Census, 2006.

Source: Figure 2 Map Data "B" @ 2018 Goggle Earth. Showing the Locations of Ikeja, Ojodu, Ikorodu etc. in Lagos State.

A close look at Figures 1 & 2 will show that three of the study locations are in the Islands (Lagos Island, Victoria Island, and Lekki) of Lagos State while the other three (Surulere, Apapa, and Ikeja) are in the mainland areas of Lagos State.

Two sets of questionnaires were designed to guide the data collection surveys. The first one was used for scheduled interviews with the Station Managers/Engineers, while the second one was used for random interview of GSM subscribers in the selected locations. On the one hand, snow-balling technique was used in administering the data collection instrument to 36 Station Managers /Engineers identified in all the GSM network service providers in Lagos State, and the frequency distribution across the various companies is as indicated in Table 5. On the other hand, a total of 845 self-administered questionnaire were randomly drawn from GSM subscribers in the seleceted locations in metropolitan Lagos comprising of: Lagos Island, Victoria Island, Lekky, Apapa, Surulere, and Ikeja. The instrument used for the GSM subscribers was designed to capture data in two sections tagged sections 'A' and 'B' respectively. Section "A" focused on collecting socio-economic data (gender, occupation, number of GSM networks subscribed to, number of years of using GSM phone) measured in categorical (dichotomous, polytomous), continuous (discrete continuous, continuous interval) scales. While section "B" was focused on capturing GSM network brand loyalty variables. Variables in this section were measured as continuous variable using 5points equal intervals Likert Scale ranging from 1= Not Important to 5 = Very Important. The analysis of the study was based on data collected from sections "A" and "B" of the questionnaire. The Cronbach alpha reliability test analysis of the instrument revealed overall mean reliability coefficient of .82 (82%); which implies that the instrument was good and reliable according to Pallant (2005).

ANALYSES, RESULTS AND DISCUSSION

The Analyses were based on copies of two sets of questionnaires administered on the respondents sampled in this survey. The first set consisted of 36 copies of questionnaire administered on station managers/engineers, while the second set was made up of 832 copies of the second instrument which were accepted after screening the questionnaire administered on GSM subscribers.

In the first set of questionnaire, the Station Managers/Engineers sampled in the network providing companies were asked to respond or provide ranking using *a 5-points equal distances Likert Scale* for statements each of which was focused on a specific variable measuring telecommunication infrastructure condition construct as in:

Var. 1. Availability Of Public Infrastructure: (Var.1_1. Power Supply (Public Mains, and **Var.1_2.** Public Security);

Var. 2. Regulation And Fiscal Challenges: (Var.2_1. Multiple Regulatory Authorities (MRA), **Var.2_2.** Multiple Taxation (MT), and **Var.2_3.** Currency Devaluation - CD);

Var. 3. Industry Practices: (Var.3_1. Share Facilities in Colocation Sites (SFCS), and **Var.3_2.** Active Infrastructure Sharing - AIS); and

Var. 4. Human Resources: (Var. 4 _1. Competency, and **Var. 4_2.** Performance Awards).

While in the second set of the questionnaire, GSM subscribers across randomly sampled in the survey were also asked to respond or provide ranking using *a 5-points equal distances Likert Scale* for statements each of which was focused on a specific variable measuring GSM brand loyalty construct as in:

Var. 5. Service Quality,

Var. 6. Complaints Resolution Time

Var. 7. Stability of Service, and

Var. 8 Network Coverage

The results of the analyses are presented and discussed below in that order (responses from Station Managers/Engineers, thereafter, responses from GSM subscribers) in line with the objective and hypothesis of the study which have earlier been stated as: To ascertain information on the condition of telecommunication infrastructure in Lagos State and its linkages with: service quality, complaints resolution time, stability of service provided, and network coverage as they influence telecommunication service consumers' brand loyalty.

Descriptive Analyses

The results of the descriptive analyses of the data from the two sets of questionnaires earlier highlighted in the preceding discussions are presented in Tables 5 and 6 for telecommunication infrastructure condition, and GSM brand loyalty determinants among network subscribers in the study area respectively.

Var. 1. Availability Of Public Infrastructure

The data on the Table 5 shows that public electricity mains supply is inadequate (mean score value range: 1.2 to 1.4) for all the networks. This low mean score (1.2 to 1.4) on a 5 points Likert Scale indicates inadequacy of public electricity supply to support telecommunication infrastructure in Lagos State, Nigeria.

On the issue of public security, analysis of the responses collected also indicated very mean score range between 1.9 and 2.25. This implies that, all the respondents agreed that public security system is somewhat low for effective security of their installations.

Var. 2. Regulation And Fiscal Challenges

Generally, analyses of the responses to the questions and ranking of statements made on this construct revealed that occurrence of each of the three variables constitute a challenge to the telecommunication industry (MRA mean score range = 4.6 – 5, and MT mean score range = 4.2 – 5), however currency devaluation stands out as a major challenge with maximum mean score value of 5. Existing literature has already pointed out that use of double regulatory authorities is inimical to progress in telecommunication industry (Ghassan et. Al., 2007).

Var. 3. Industry Practices: (Var.3_1. Share Facilities in Colocation Sites (SFCS), and **Var.3_2.** Active Infrastructure Sharing - AIS);

The result of analyses of these questions show that all the GSM network providers consider these two aspects of industry practices to be important, however, the data reveal that MTN places more premium on these practices (mean score 4.6 for both). This implies that for MTN, the practice of SFCS and AIS tend toward being very important and not just important as was the case with Glomobile, Airtel, and Etisalat.

Table 5: Descriptive Statistics of Telecommunication Infrastructure Condition Variables

Variables	Operator	N	Mean	Std. Deviation	Std. Error Mean
Var. 1. AVAILABILITY OF PUBLIC INFRASTRUCTURE					
Var.1_1. Power Supply (Public Mains)	MTN	13	1.2	1.122	.036
	Glomobile	10	1.4	1.211	.018
	Airtel	8	1.31	1.51	.025
	Etisalat	5	1.25	2.12	.031
Var.1_2. Public Security	MTN	13	2.1	1.122	.036
	Glomobile	10	2.0	1.211	.018
	Airtel	8	1.9	1.51	.025
	Etisalat	5	2.25	2.12	.031
Var. 2. REGULATION AND FISCAL CHALLENGES					
Var.2_1. Multiple Regulatory Authorities	MTN	13	4.6	1.122	.036

	Glomobile	10	4.8	1.211	.018
	Airtel	8	4.71	1.51	.025
	Etisalat	5	5.0	2.12	.031
	MTN	13	4.52.	1.201	.042
Var.2_2. Multiple Taxation	Glomobile	10	4.6.	1.30	.024
	Airtel	8	4.55	2.101	.016
	Etisalat	5	5.0	1.210	.050
	MTN	13	5.0	1.266	.041
Var.2_3. Currency Devaluation	Glomobile	10	5.0	1.156	.046
	Airtel	8	5.0	1.132	.038
	Etisalat	5	5.0	1.512	.040
Var. 3. INDUSTRY PRACTICES					
	MTN	13	4.6	1.122	.036
Var.3_1. Share Facilities in Colocation Sites	Glomobile	10	4.2	1.211	.018
	Airtel	8	3.7	1.51	.025
	Etisalat	5	3.5	2.12	.031
	MTN	13	4.2	1.107	.036
Var.3_2. Active Infrastructure Sharing	Glomobile	10	4.6	1.401	.051
	Airtel	8	4.25	1.024	.050
	Etisalat	5	4.3	1.010	.040
Var. 4. HUMAN RESOURCES					
	MTN	13	4.6	1.201	.042
Var. 4 _1. Competency	Glomobile	10	4.2	1.30	.024
	Airtel	8	3.8.	2.101	.016
	Etisalat	5	3.82	1.210	.050
	MTN	13	4.1	1.30	.042
Var. 4_2. Performance Awards	Glomobile	10	3.8	1.20	.024
	Airtel	8	3.0	2.10	.016
	Etisalat	5	2.1	1.25	.050

Source: Field Survey, 2019

Var. 4. Human Resources:

A close look at the data on the table shows that staff competency consideration is tending towards very important status for MTN (mean score value = 4.6), while the same variable is considered to be a little more than being important by Glomobile respondents (mean score value = 4.2). Lastly, staff competency is getting very close to being important for Airtel and Etisalat (mean score value = 3.8, and 3.82 respectively).

Similar trend is also visible with respect to performance recognition and granting of performance awards to staff on the table where MTN is followed by Glomobile, Airtel, and Etisalat with mean scores of 4.1, 3.8, 3.0, and 2.1 respectively).

Var. 5. Service Quality

Taking a similar look on Table 6 reveals that the service quality of Glomobile, and Airtel in survey areas were ranked good (4.21 & 4.0 respectively), while that of MTN was ranked significantly higher than good at mean score = 4.36); however, the mean score (3.98) of the service quality for Etisalat GSM subscribers is barely itching towards being good.

Table 6: Descriptive Statistics of GSM Network Subscribers Brand Loyalty Variables

Variables	Network Subscribers	N	Mean	Std. Deviation	Std. Error Mean
Var. 5. SERVICE QUALITY	MTN	332	4.36	1.1	.036
	Glomobile	224	4.21.	1.21	.018
	Airtel	149	4.00	1.51	.025
	Etisalat	127	3.98	2.12	.031
Var. 6. COMPLAINTS RESOLUTION TIME	MTN	332	3.86	1.12	.036
	Glomobile	224	3.56	1.21	.018
	Airtel	149	3.45	1.51	.025
	Etisalat	127	3.50	2.12	.031
Var. 7. STABILITY OF SERVICE	MTN	332	4.60	1.12	.036
	Glomobile	224	4.80	1.211	.018
	Airtel	149	4.71	1.51	.025
	Etisalat	127	3.50	2.12	.031
Var. 8 NETWORK COVERAGE	MTN	332	4.52	1.20	.042
	Glomobile	224	4.10	1.30	.024
	Airtel	149	3.86	2.101	.016
	Etisalat	127	3.65	1.210	.050

Source: Field Survey, 2019

Var. 6. Complaints Resolution Time

The result of the analysis of responses and ranking of statements on complaints resolution time displayed on Table 6 shows mean score values of 3.86 and 3.56 respectively for MTN and Glomobile. While Airtel and Etisalat scored 3.45 and 3.50 respectively on the same variable. The implication of the result of this analysis is that all the networks in the study area are on the verge of raising customers' complaints resolution outcome to the point of being rated good by the network users.

Var. 7. Stability of Service

Data on Table 6 indicates that Glomobile (Mean Score Value = 4.80) network provides the most stable service in the study area as at the time of this survey, while MTN, Airtel, and Etisalat scored 4.6, 4.71, and 3.50 respectively on the same variable. Considering the high stability of service mean value range (4.6 - 4.8) scored by Glomobile, MTN, and Airtel, it suggests that GSM service from most service providers in Lagos State is stable.

Var. 8 Network Coverage

Similar trend can also be observed with respect to network coverage, where the data on the table shows MTN leading in coverage with (4.52 mean score value), followed by Glomobile (4.10 mean score value), while Airtel and Etisalat scored 3.86, and 3.64 respectively on the same variable.

The analyses further extended into examining the relationships between the telecommunication infrastructure condition with a focus on finding out how improvement action taken on each of the variables will affect the other variables of the construct.

Table 7: Respondents' perception of the importance telecommunication infrastructure condition to GSM Brand Loyalty

Telecommunication Infrastructure Condition Variable	Minimum	Maximum	Mean	Ranking
Adequate Public Power Supply	1	5	4.25	1st
Stable Currency Exchange Rate	1	5	3.86	2nd
Staff Competency	1	5	3.81	3rd
Adequate Public Security	1	5	3.76	4th
Adoption of Single Regulatory System	1	5	3.61	5th
Performance Awards	1	5	3.57	6th
Eradication of Multiple Taxation	1	5	3.31	7th
Share Facilities in Colocation Sites	1	5	3.29	8th
Active Infrastructure Sharing	1	5	2.70	9th

Source: Field Survey, 2019

Table 7 revealed that to the station managers and engineers of the network proving companies, adequate supply of public electricity ranks 1st in the importance of telecommunication infrastructure conditions, followed by: stable currency exchange rate 2nd , staff competency 3rd, adequate public security system 4th, use of single regulatory system 5th, policy of performance awards to deserving staff members 6th , eradication of multiple taxation 7th, deepening industry policy in sharing of facilities in colocation sites 8th , and active infrastructure sharing 9th respectively.

The implication of the above result is that substantial improvement in the condition of public infrastructures (electricity and security) in Nigeria is required for improvement in telecommunication industry services delivered to GSM subscribers which will promote brand loyalty among GSM users in Nigeria. It also points to the industry's need for the dividends of good governance to provide stable economic condition with stable local currency exchange in value. Nevertheless, the data on the table portrays opportunity for sharing of facilities in the industry. Ehiagwina, and Fakolujo (2015); Nosiri, et. al. (2014); Olusegun, (2014); Shruti, (2013); Idachaba (2010); Keamey, and Bala-Gbogbo, (2009); and Onwuegbuchi, (2009) rightly emphasized industry benefits arising from sharing of facilities e.g., cost, and environmental noise reduction, etc.

Going further in the analyses, in pursuit of the objective of this study, Pearson Product Moment Correlation Coefficient was used to explore relationships between the four telecommunication infrastructure condition variables and four GSM brand loyalty variables namely: availability of public infrastructure, regulation and fiscal challenges, industry practices, human resources, service quality, complaints resolution time, stability of service, and network coverage.
Result of the analysis is shown as a correlation value matrix between the telecommunication infrastructure condition, and brand loyalty variables in Table 8

Table 8: Correlation Matrix of Telecommunication Infrastructure Condition and GSM Brand Loyalty Variables in Lagos State, Nigeria

Independent Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1. Availability of Public Infrastructure	1							
2. Regulation & Fiscal Challenges	.02	1						
3. Industry Practices	.2	.54*	1					
4. Human Resources	.03	.35	.35	1				
5. Service Quality	.82*	-.53*	.65*	.75*	1			
6. Complaints Resolution Time	.68	-.45	.61*	.81	.62*	1		
7. Stability of Service	.71*	-.52	.71*	.64	.58	.79	1	
8. Network Coverage	.62*	-.60*	.60*	.54	-.35	.56	.5	1

****Correlation is significant at the 0.001 level (2-tailed)**
Source: Field Survey, 2019

With less than 0.001 probability, the correlation coefficient (r) values in Table 8 would not have occurred by chance in a sample size of 868 as the probability is tending towards zero, and the asterisks indicate the significantly correlated variables. Table 8 shows that on the one hand telecommunication infrastructure condition variables correlate positively with GSM brand loyalty variables. Result of the correlation analysis showed the degree of strength and direction of the relationship between telecommunication infrastructure condition, and GSM brand loyalty variables.

Close examination of the data on the first column reveals that availability of public infrastructure strongly positively correlates with all the variables of brand loyalty with maximum correlation coefficient (r) value of .82 (service quality), and the least (r) value of .62 (network coverage). The data on the second column portrays a somewhat curious trend as it indicates that regulation and fiscal challenges moderately negatively correlates with quality of service (r = -.53), complaints resolution time (r = -.45), service stability (-.52), and strongly negatively correlates with network coverage (-.60).

The implication of the negative correlation is that use of multiple regulatory authorities and multiple taxation system reduce the ability of telecommunication industry operators to provide stable service, promptly resolve GSM users' complaints, and expand service coverage area. On the third column, industry practices strongly positively correlate with all the GSM brand loyalty

variables with maximum correlation coefficient (r) value of .71 (stability of service), and the least (r) value of .60 (network coverage).

Furthermore, it is glaring from the table that no relationship exists between availability of public infrastructure, regulation & fiscal challenges, industry practices, and human resources at correlation coefficient (r) value range of .02 - .2. While industry practices moderately positively correlate with regulation and fiscal challenges at correlation coefficient value r = .54.
The findings of the correlation analysis conform with the a` prior expectation which anticipates that telecommunication infrastructure plays significant role in socio-economic activities smart cities. Therefore, the study rejected the null hypothesis that there is no significant relationship between telecommunication infrastructure condition and GSM brand loyalty in Lagos State, Nigeria while the alternate hypothesis was accepted.

CONCLUSION AND RECOMMENDATIONS

This concludes that telecommunication infrastructure condition positively correlates with GSM consumers brand loyalty. The existing state of inadequacy of public infrastructure (electricity and security) presents a challenge to GSM network providing companies in Nigeria. The poor state of public electricity, and security infrastructure have resulted in higher operational cost as the industry operators currently use privately generated electricity most of the time. In addition, despite the official security arrangement with the Nigerian Police force in the neighbourhood, the telecommunication companies also incur extra cost for providing 24 hours private guards around their installations, and office premises. This private provision of electricity and security by telecommunication industry operators because of the inadequacy of public infrastructure in Nigeria affects industry profitability, productivity, wealth creation and the capacity to create employment in Nigeria.

In order to attain the expected business trade-off, telecommunication industry, may end up passing a portion or all of these extra costs to GSM subscribers in one way or another. Increasing the cost of GSM phone usage as a means cushioning the infrastructure motivated extra cost directly impacts negatively on a GSM user's economy which will indirectly negates the smart city aspirations and urban virtual connectedness.

The current infrastructure challenges tend to hinder telecommunication industry from tapping the benefits of economies of scale through wider spreading of transmitting and receiving stations as such business pursuit will automatically attract a significant per capita electricity and security cost, especially in low tele-density areas.

This study recommends increased government funding for the provision and improvement of the state of public electricity and general security in Lagos State and other states of Nigeria for cheaper telecommunication business operation costs. Cheaper industry cost profile will result in better service delivery in support of the attainment of smart city aspirations of Lagos State.

Competing interests

This author declare that this is an independent report of an empirical survey carried out in Lagos State between 2020 and 2021, and that the author has no financial or personal relationships with any organization or individual as to inappropriately influence the content of this article.

REFERENCE

Achumba, I.C., Ighomereho O. S. and Akpor-Robaro M. O. M. (2013). Security Challenges in Nigeria and the Implications for Business Activitie sand Sustainable Development, Journal of Economics and Sustainable Development, 4(2).

Akinola, S. R. (2007). Coping with infrastructural deprivation through Collective Action among Rural People in Nigeria. Nordic Journal of African Studies, 16(1), pp 30-46

Alleman, J., Hunt, C., Michaels, D., Mueller, M., Rappoport, P. and Taylor, L. (2016). Telecommunications and Economic Development: Empirical Evidence from South Africa. [Monograph of International Telecommunications Society of Sydney in Collaboration with University of Colorado].

Deloitte (2015). Smart cities...Not just the sum of its partshttps://www2.deloitte.com/content/dam/Deloitte/xe/Documents/strategy/me_deloitte-monitor_smart-cities.pdf

Ehiagwina O. F. Fakolujo O.A. (2015). Mobile cellular network infrastructure sharing models among GSM network operators: A Technical Review. Proceedings of The International Academic Conference for SubSahara African Transformation & Development 2015.

Ghassan H. Bahjat El-D. Mohamad M. Louay A.C. (2007). "Telecom Infrastructure Sharing Regulatory Enablers and Economic Benefits". Booz Allen Hamilton, Perspective Report.

Idachaba, F.E. "Telecommunication Cost Reduction in Nigeria through Infrastructure Sharing between Operators". Pacific Journal of Science and Technology. 11(1):272-276, 2010.

Ijewere, A.A. and Gbandi, E.C. (2012). Telecommunications reform in Nigeria: The marketing challenges. *JORIND **10 (2).*** ISSN 1596 - 8308. www.transcampus.org./journals, www.ajol.info/journals/jorind 193

Keamey A.T., and Bala-Gbogbo E. (2009). Mobile network operator: Network sharing 1+1=1 [10] "Telecom Industry Operators Opt for Infrastructure Sharing".

Nosiri O.C., Onoh G.N, Chukwudebe G.A. Azobogu A.C. (2014). "Sideband Noise Mitigation in a Co-located Network Involving CDMA2000 and WCDMA system" *American Journal of Networks and Communications **3(2):*** 17-24, 2014.

Olusegun A.O. (2014). Tech, telecom contribute 10 percent of Nigeria's GDP. [ICT Monograph] Retrieved from www.pcworld.com/article/2860252/

Onwuegbuchi O. (2009). Co-location an imperative for CAPEX reduction. Nigeria communicationsweek.com.ng.

Richard Hu, R. (2019). The State of Smart Cities in China: The Case of Shenzhen Energies 12(22):4375 DOI:10.3390/en12224375 Accessed from https://www.researchgate.net/publication/337325930_The_State_of_Smart_Cities_in_China_The_Case_of_Shenzhen/link/5dd296244585156b351d2b65/download

Roland Igbinoba Real Foundation for Housing and Urban Development (2009). The state of Lagos housing market. Electronic version retrieved from.

http://www.pisonhousing.com/The%20State%20of%20Lagos%20Housing%20Market.pdf Accessed on 9th November, 2013.
Shruti B. (2013). "Infrastructure sharing in telecom industry; growth of new business models and their prospective trends". [Monograph of Institute of Telecom management Pune, India].
The Nigerian Communications Commission (2011). Retrieved from http://www.ncc.gov.ng/index
The Nigerian Communications Commission (2015). Retrieved from http://www.ncc.gov.ng/index
The Nigerian Communications Commission (2019). Retrieved from http://www.ncc.gov.ng/index
The Nigerian Communications Commission (2020). Retrieved from http://www.ncc.gov.ng/index

Bibliography

An article from Thisday newspaper, 2013. www.thisdaylive.com/articles/johnson/151645
LASIMRA TO COMMENCE TELECOM SITE INSPECTION
https://lagosstate.gov.ng/blog/2017/08/11/lasimra-to-commence-telecom-site-inspection/