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EQUIPMENT CO-LOCATION AND INFRASTRUCTURE SHARING ON THE PERFORMANCE OF MOBILE NETWORK OPERATORS IN ENUGU STATE NIGERIA.

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Abstract

The study focused on the impact of equipment co-location and infrastructure sharing on the performance of mobile network operators in Enugu state, Nigeria. The study was guided by three objectives thus, to examine the effect of passive sharing on the operation of mobile network operators in Enugu state Nigeria, to evaluate the effect of active sharing on the capacity expansion of mobile network operators in Enugu state Nigeria, and to ascertain the effect of spectrum sharing on the efficiency of mobile network operators in Enugu state Nigeria. The study adopted descriptive survey in which quantitative analysis was used to analyse the data from 52 respondents sampled from MTN, Globacom, Airtel and 9Mobile, using the Yamane sampling method and Bourley's sample proportion allocation technique. Inferential statistics was also used to test the formulated hypotheses. The results were presented in forms of mean and standard deviation. The result showed that the MNOs under study have embraced passive sharing in Enugu state, not only as regulatory requirement but also as an innovative means of enhancing their operations. Similarly, it was found that active sharing has significant effect on the capacity expansion of the MNOs. This result was arrived through a quantitative analysis that gave an average mean response of the respondents as 4.24 out of possible 5.0 with a standard deviation of 0.90. The study further revealed that spectrum sharing by the MNOs improve their efficiency, despite the challenges associated with the practice. This result was arrived at through a descriptive statistic that showed that the average mean response of the respondents is 4.40 with a standard deviation of 0.73. This result means that the MNOs almost strongly agree that equipment co-location and infrastructure sharing improve their efficiency. The study therefore concluded that co-location and

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infrastructure sharing is vital in deepening mobile network penetration in Enugu state. Given this, it was recommended that the Nigerian Communications Commission (NCC) should further encourage the MNOs to co-locate more of their equipment and share more infrastructures.

1.1 Introduction

Co-location of telecommunication infrastructure is a process where two or more operators share different infrastructure in a particular site as a mechanism for cost reduction, quality of service improvement and rapid network expansion while at same time creating a positive environmental impact with good economic sustainability (Lusungu, 2018). The growth of the telecom market in Nigeria has continued at a geometric rate characterized by large geographical spread. According to (Olusegun, 2019), the Nigerian telecommunication market is one of the fastest growing telecommunication markets globally. This growth as well as network maturity becomes a very important aspect that requires adequate measures to curb the huge cost and burden incurred on telecoms investors and operators as they continue to expend huge capital expenditures on telecommunication assets and infrastructure in a bid to gain and sustain the competitive market.

Due to the increase in competition along with new investments in the wireless communication industry, the decline in Average Revenue per User (ARPU) and Revenue-On-Assets (ROA) has been pushing Nigerian telecommunication operators towards new techniques to maximize profit. In a reasonable point of view, network operators are required to play a fundamental role to support the economic and social development of a nation. Their contribution is critical in meeting enhanced policy objectives across the entire economy. Hence the need becomes paramount for all network operators to see infrastructure sharing as a necessary tool for network optimization.

Infrastructure sharing is not new in the telecommunication industry. Globally, Infrastructure sharing started materializing in 2001 (Ghassan et al., 2017). With the hype of 3G licensing in Europe and the big investments made in license acquisition, many operators were under pressure to share deployment costs and thus share infrastructure as means of reducing their rollout costs (Ghassan et al., 2017). Today, Infrastructure sharing agreements are very advanced in developed countries. An interesting example of infrastructure sharing is a tower company in India, Indus Towers, which claimed to be the world largest independent tower company having over 100,000 towers and having the capacity to rent out to the numerous operators in India (Telecom Infrastructure industry in India, 2020).

From a general perspective, many regulators recognize infrastructure sharing as an essential element to fostering services-based competition and a means to limit adverse environmental impacts of network rollout. In fact, most regulators in the western world imposed facilities-sharing requirements on the telecommunication operators that are not service specific in order to facilitate economically efficient use and investment in infrastructure (Ghassan et al., 2017). However, in Africa, the infrastructure sharing initiative is being sluggishly implemented as a result of resistance from either the regulatory bodies or the network operators. Though, the approach has already seen significant economic improvement in some parts of the continent. Nigeria still has a majority of telecommunication towers owned by individual mobile network operators, despite the fact that the country has been one of the first markets in Africa to introduce the tower outsourcing model (Nosiri et al.,)

However, some network operators have seen reasons and the accrued benefits in site sharing while some other operators still never thought otherwise. Business Monitor International (2018), revealed that some major wireless

network operators in Nigeria such as MTN, 9 Mobile, Airtel and Visaphone are lethargically adopting infrastructure sharing strategy while GLOBALCOM operators are still pursuing the policy of doing it alone as well battling with the idea of being the first to reach certain subscriber base through expansion without regard to its implications on the already high cost of doing business in the country. They centred on the struggle to gain more customers on the ground of better network coverage. They felt that sharing tower assets would mean giving away the advantages of a wider and better network.

In view of the prospects offered by co-location of telecommunication infrastructures, it is pertinent to explore the value of infrastructure sharing as a means of achieving cost efficiency, economic sustainability, rapid network expansion/optimization and revenue assurance the Nigerian telecommunication industry in Enugu State. It also geared towards encouraging the key players in mobile network industry in Nigeria, especially those that are not collaborating with the policy to embrace the strategy for economic benefit, low tariff, and good quality of service.

1.2 Statement of the Problem

The growth of the telecoms market in Nigeria has continued at geometric rates thereby sustaining the market as one of the fastest growing telecoms market globally. This growth, however, has brought with it a huge cost burden on telecoms investors and operators as they continue to expend huge capital expenditures on telecoms assets and infrastructure in a bid to gain and sustain competitive advantage. Today, as the telecoms market in Nigeria nears maturity, the average revenue per user (ARPU) and revenue-on-assets (ROA) indices begin to dip, telecoms operators in Nigeria are beginning to desperately explore new ways of reducing their capital expenditures (CAPEX) and operational overheads/cost on telecoms infrastructure.

Conventional mobile network operation scheme is marked by vertical integration where the mobile network operator purchases and build the sites needed for rolling out the network, design the network architecture, operates, controls and maintains the network and customer services relationships, gain market share and provides services to customer-individual and corporate. While, technology migration, such as the launching of third generation (3G) and 3.5G wireless technologies on top of 2G networks, and the introduction of 4G technologies including LTE, is becoming increasingly rapid and complex (Falz, 2020). Regulatory requirements also mandate coverage of areas that is not attractive from a business perspective. With growing competitive intensity and rapid price declines, mobile operators are facing increased margin pressure and the need to systematically improve their cost position.

In current market environment, focusing merely on the provisioning of coverage and capacity has a relatively low success factor, and to address this reality, operators are adopting multiple strategies, with network sharing emerging as a more radical mechanism to substantially and sustainably improve network costs. Mobile infrastructure sharing in telecom is an important measure to reduce costs. It is useful in startup phase to build coverage quickly and in the longer term scenario to build more cost effective coverage, especially in rural and less populated or marginalized areas. In the emerging market context, both in urban and rural areas infrastructure sharing should be adopted as an imperative for sustained telecom growth.

Also, the Nigerian independent National Regulatory Authority, the NCC (Nigerian Communications Commission) has given its support to this new model and has also developed a regulatory framework for potential Access Providers and Access Seekers to share infrastructure to promote fair competition and promote infrastructure sharing amongst telecoms licensees.

1.3 Objectives of the Study

The aim of the study is to evaluate the impact of equipment co-location and infrastructure sharing on the performance of mobile network operators in Enugu state Nigeria. The specific objectives are:

i. To examine the effect of passive sharing on the operation of mobile network operators in Enugu state Nigeria.
ii. To evaluate the effect of active sharing on the capacity expansion of mobile network operators in Enugu state Nigeria.
iii. To ascertain the effect of spectrum sharing on the efficiency of mobile network operators in Enugu state Nigeria.

1.4 Hypothesis of the study

i. Passive sharing has no significant effect on the operations of mobile network operators in Enugu state Nigeria.
ii. Active sharing has no significant effect on the capacity expansion of mobile network operators in Enugu state Nigeria.
iii. Spectrum sharing has no significant effect on the efficiency of mobile network operators in Enugu state Nigeria.

Review of Related Literature

2.1 Conceptual Review

Infrastructure Sharing in Telecom Industry

Telecom infrastructure co-location has been defined as an arrangement whereby two or more telecom service providers can agree to share infrastructure located in a common place or area for the purpose of reducing capital and operational expenditure (Bala-Gbogbo, 2019). In this new model, competitors are becoming partners in order to lower their increasing investments and the degree and method of infrastructure sharing can vary in each country depending on regulatory and competitive climate. In other literatures telecom infrastructure co-location is referred to as Local Loop Unbundling (LLU or LLUB) which implies the regulatory process of allowing multiple telecommunications operators to use connections from the telephone exchange's central office to the customer's premises. There are three dominant forms of sharing possibly deployed worldwide. They include passive sharing, active sharing and spectrum sharing.

i. Passive Sharing

In this form of sharing, operators agree to share available non-electronic equipment which includes site space, buildings and easements, towers and masts and power supply (Ghassan, et al., 2017). This technique is suitable especially in densely populated areas with limited resource availability, in rural areas that are uneconomical to serve and where new site acquisition is difficult. It is the simplest form of infrastructure sharing adopted by mobile network operators.

ii. Active Sharing

Involves sharing of electronic components and facilities such as base station equipment, microwave radio equipment, switching centres, sharing common network both circuit-switched and packet-oriented domains, antennas and receivers (Bala-Gbogbo, 2019). Each operator, however, has its own individual home network that contains the independent subscriber databases, services, subscriber billing, and connection to external networks. Active sharing requires additional planning and deployment efforts to accommodate each participating operator's capacity needs (Falz, 2020).

iii. Spectrum Sharing

This is also known as spectrum trading, it is a model that has recently developed in mature, regulated telecom markets (Falz, 2020). It involves operators leasing their spectrum to other operators on commercial terms. Because spectrum is a scarce resource that may often be underutilized by one operator in a given area, spectrum sharing remains a viable option for two or more operators.

Telecommunication Industry in Nigeria and the Inherent Constraints

There are various challenges confronting mobile network operators in Nigeria. These challenges impede the faster deployment of services to the underserved area and evidently, hinder the rapid growth and network expansion. Some of the challenges include sharp rising of site rentals, tower restriction and huge cost of demand by the government agencies. Others include erratic power supply, security threat and vandalization of network equipment.

i. Sharp Rising of Site Rentals

Site acquisition remains a key aspect in establishing and building a cell site. Many operators are challenged by the high rising cost of site rentals. Site owners are now aware of more players desiring to rollout in urban and rural areas and hence the demand for tower sites and rentals are expected to continue to rise sharply on daily basis (Emeka, 2022).

ii. Tower Restrictions and Huge Cost Demand:

Both the urban planning ministries and local government authorities, as well as state governments place restrictions on new tower constructions on the grounds that they pose health hazards and distorts the beauty of the landscape. This unfriendly operating environment which has made the installation of base stations difficult because of the restrictions and huge demand from government agencies and the host community remain a constraint. To build a base station requires several approvals that operators must secure from government regulatory agencies such as Nigerian Communications Commission (NCC), National Environmental Standards Regulatory Enforcement Agency (NESREA), Federal Ministry of Environment (FME), State Ministry of Environment (SME), Local Government Agency (LGA), Federal Environment Protection Agency (FEPA) and Town Planning Authorities (TPA) where the mobile operators must get approval irrespective of other existing unfavourable conditions which also required urgent attention. According to the Industry Working Group (IWG), telecommunication companies in Nigeria were fleeced of over 900 billion naira (3.75 billion USD) yearly by the state, local government and their agencies (Onwuegbuchi, 2019).

iii. Power Issue

The growth and expansion of mobile telecom networks depends on key support infrastructure centered on availability of power supply. Power supply, plays a major role in running the mobile network with a benchmark network uptime of 99.98% in order to maintain the reliability and quality of service (Ghassan, et al., 2017). Operators have to keep their networks running on continuous bases 24 hours a day, 365 days a year, regardless of utilization. Demand for service may drop to zero during night hours on certain sites but operators have no option to switch the site off during these hours as they cannot predict subscriber movements. Grid power supply is a major concern in Nigeria and has affected telecom operations in terms of costs, reliability and efficiency. About 75% of the sites are off-grid and usually powered by diesel generators with huge Operational Expenditure (OPEX). The remaining grid-connected sites still suffer due to the poor quality of power supply and frequent outages lasting over hours. This had also led to a heavy dependence on diesel generators even for the grid-connected sites. A typical base station requires 3000watts to power a mobile telecommunication equipment in a cell site and is powered by two (2) 20 KVA generators running alternatively (Idachaba, 2020).

The use of diesel generators as a source of energy supply for cell sites require regular re-fueling and adequate maintenance. These conditions remained unfavourable considering the ever-increasing cost of purchasing diesel. Diesel constitutes a major chunk (93% of the direct costs of power) of powering telecommunication equipment in Nigeria, due to the poor grid power supply consuming up to 66% of the total OPEX cost for cell sites (Idachaba, 2020).

Meanwhile, Operators typically ensure that their systems have backup mechanism such as battery banks to ensure continuity of service and business operations. The cost of running and maintenance of the batteries are quite expensive. Therefore, the use of diesel generators as the default power backup of off-grid and grid connected telecom tower sites comes with its implicit disadvantages in terms of high cost of power, diesel logistics and theft, as well as having a negative environmental impact due to high carbon dioxide (CO_2) emission per kWh consumed. In addition to the poor grid power supply, Nigerian telecom operators face operation challenges. Site security is a major issue as there have been several cases of damage to tower assets across the country. This risk has hindered the mobile network operators to achieve their aims in delivering quality service as well rapid expansion of their networks. Thefts of equipment and vandalization have affected the OPEX of telecom sites. The terrorist group known as Boko Haram, ISWAP and lately Bandits have further created difficulties for network availability and maintenance in the northern states of Nigeria, a dilemma which neither the government nor network operators are properly positioned to address.

The Need for Passive Infrastructure Sharing in Nigeria

The desire of wireless service providers in Nigeria to build more base stations have been accelerated by the need to provide coverage to geographic regions where the service provider has not previously served, fill in "dead spot" and areas where existing signals are weak or non-existence and meet the higher speed requirements of emerging technologies. The drive to meet these needs had led to the proliferation of new cell towers which are capital intensive, pose environmental health hazards and distorts the beauty of the environment (Nosiri, Onoh et al., 2014). The rapid growth in wireless mobile subscribers in Nigeria has been outstanding and recently escalating above 140 million subscribers (Nosiri, Agubor et al.,). The major players of mobile network providers in Nigeria are MTN, GLOBALCOM, AIRTEL, and 9 MOBILE.

Due to the increase in subscribers' growth as well with the heated competition among rivals, it becomes paramount for faster deployment of telecommunication infrastructure to further consolidate the socio-economic benefits of having efficient communication infrastructure devoid of high tariff. Telecommunication industry in Nigeria do not have adequate infrastructure to shield the pressure generated by this rapid increase in demand for telecom services by the end users.

The cost of building the cell site is capital intensive, poses environmental threat and distorts the beauty of the landscape. It becomes necessary for the key players to consolidate in tower sharing as optimized strategy for reducing the heavy cost burden in network rollouts, expansions, and upgrades. This is essential due to the increasing competition in telecom industry in Nigeria which is forcing the average revenue per user (ARPU) down and also the need for quality-of-service delivery in the form of site uptime. The current market uptime average is around 70% which will no longer be sufficient in a competitive environment (Falz, 2020).

One of the conditions that necessitates or promotes tower sharing requires a mature network and a growing market. This condition is matured in Nigeria telecom industry; hence the urgent need for collaboration and consolidation (Idachaba, 2020).

The Regulatory Perspective

Many national regulatory agencies around the world are driven to favour infrastructure sharing as a way of stimulating competition and hence they are beginning to formulate policies that would regulate and encourage sharing of infrastructure among telecom companies as a key lever to foster competition and optimize telecom investments (Chanab et al, 2007). For these NRAs, infrastructure sharing limits duplication and gears investments towards underserved areas, product innovation, and improved customer service (Chanab et al, 2007).

The Nigerian Communications Commission (NCC), which is the telecoms regulatory authority, favours infrastructure sharing and has developed what it calls Guidelines on Co-location and Infrastructure Sharing" as a framework for infrastructure sharing among telecom operators in Nigeria. The following were given as the objectives of these guidelines:

i. To ensure that the incidence of unnecessary duplication of infrastructure is minimized or completely avoided.
ii. To protect the environment by reducing the proliferation of infrastructure and facilities installations.
iii. Promote fair competition through equal access being granted to the installations and facilities of operators on mutually agreed terms.
iv. To ensure that the economic advantages derivable from the sharing of facilities are harnessed for the overall benefit of all telecommunications stakeholders.
v. To minimize capital expenditure on supporting infrastructures and to free more funds for investment in core network equipment.
vi. To encourage operators to pursue a cost-oriented policy with the added effect of a reduction in the tariffs chargeable to customers.

According to the NCC, infrastructures amenable to sharing are those that can be shared without an attendant risk of lessening of competition. The Commission (NCC) also encourages and promotes the sharing of the following infrastructures:

Rights of Way, Masts Poles, Antenna masts and tower structures, Ducts, Trenches, Space in buildings, Electric power (public and private source).

Challenges confronting passive infrastructure sharing in Nigeria

One of the challenges facing infrastructure sharing in Nigeria is the stiff competition between the operators in Nigeria. The operators are in frantic race to capture the market and as such they try to outdo each other in customer attraction and attention. Another challenge facing site sharing in Nigeria is the absence of enforceable legislation/regulation in favour of infrastructure sharing. This challenge is capitalized upon by established operators who make difficult demands on the other operators who want to share their infrastructure. These incumbent operators are usually unwilling to accept the opening of the infrastructure to other players and for new operators to trust the incumbents in providing them with the appropriate access to sites without deliberate tactical delays to prevent them from rolling out their networks effectively. Though recently, the regulatory body in Nigerian (NCC), has addressed the challenge by licensing co-location vendors such as Helios Towers, IHS, Swap Technology and MTI which is hoped to reduce the constraints.

2.2 Theoretical Framework

The Resource Based Theory of infrastructure sharing

The resource-based view is a theory that was propounded by Barney Jay in 1991 which examines the relation between a firm's internal characteristics and performance. Using this theory, the potential of firm resources to generate sustained competitive advantage is analyzed. It is based on the assumption that strategic resources are heterogeneously distributed across the firms (heterogeneous) and this distribution is stable over time (immobile). Barney (1991) specifies the conditions under which strategically relevant resources can be sources of sustained competitive advantage for a firm. The firm resources that are considered are the physical capital resources, the human capital resources and the organizational capital resources (Barney, 1991). In order for a firm's resource to generate sustained competitive advantage, the resource should be valuable, rare, inimitable and non-substitutable.

Technology Acceptance Model (TAM)

Continuing along the theme of opinions and attitudes impacting innovation adoption, Davis' (1985) Technology Acceptance Model (TAM) asserts that it is in fact a potential adopter's attitude and expectations of the innovation

that affects the chances for its adoption (Davis, 1985). Two focus concepts in TAM are how the innovation is perceived by the potential adopter related to its ease of use – how easy the innovation will be to learn and implement – and its potential usefulness – the degree to which the innovation will improve the user's personal or job-related performance (Straub, 2009). Of the two elements, Davis believed that ease of use has a direct impact on perceived usefulness as, the easier an adopter perceives an innovation to be able to use, the greater chance they will use it and experience higher productivity thus proving to be useful to the adopter (Davis, 1985). In a later study, Davis concluded that there was a higher correlation between perceived usefulness and technology adoption than between perceived usefulness and adoption. From his test results, he surmised that it would not matter how easy a technology is to learn; people would not adopt it if they did not perceive it to be useful in increasing their productivity (Davis, 1989).

2.3 Emperical Review

Arakpogun et al. (2020) carried out a study which focused on the antecedents and drivers of infrastructure sharing among local and multinational mobile network operators in Africa. The study adopted qualitative research design and literature review. The results revealed that institutional factors and technological factors are influencing the propensity of the mobile network operators to engaging in infrastructure sharing because it seemed not in tandem with the conventional competitive arrangement. More so, the study posited that in the case of low-level infrastructure sharing and lack of optimal regulation, the mobile network operators are bound to engage in more competition that further weakens the arrangement.

Sylvester et al. (2016) carried out a study titled "Infrastructure Sharing among Ghana's mobile telecommunication networks: benefits and challenges" wherein the authors focused on the cost reduction potentials of infrastructure sharing for mobile network operators in Ghana. The study adopted a mixed research design involving qualitative and quantitative approaches. The study found that infrastructure sharing has helped mobile network operators in Ghana to reduce cost and as well jettison anti-competitive tendencies.

Ehiagwina et al. (2016) carried out a study titled "An overview of multi-operator global systems for mobile communications base stations in the context of Nigerian telecommunication sector". The authors noted with concern the growing population of Nigeria and the need to deepen mobile network penetration to remote parts of Nigeria. The study relied on the review of existing literature as a methodology. It was highlighted that capital expenditure CAPEX, environmental regulations, multiple taxation among others are some of the challenges bedeviling expansion of mobile network coverage in Nigeria. To this end, the study proposed infrastructure sharing as a means of overcoming these myriads of problems.

Adekitan (2019) sought to find out if network infrastructure sharing results in a significant reduction in cost of network infrastructure rollout and capacity expansions for telecoms operators in Benue State. The study adopted descriptive survey in which involved senior technical, rollout managers, finance/accountant and administrative staff cadre of MTN and GLO working in Benue State. The sample size was 168. Multiple- Regression statistical technique was employed to predict the established relationships between the variables. The study found out that that network infrastructure sharing leads to significant reduction in cost of network infrastructure rollout in the rural areas for telecoms operators in Benue State.

Study Area

The study is carried out in Enugu state Nigeria. Enugu State is a state in the South-East geopolitical zone of Nigeria, bordered to the north by the states of Benue and Kogi, Ebonyi State to the east and southeast, Abia State to the south, and Anambra State to the west. The state takes its name from its capital and largest city, Enugu. Enugu state is widely regarded as the political headquarters of the southeast Nigeria because it was the formal

headquarters of the defunct Eastern Region. At present, Enugu state is divided into three political zones, namely Enugu North, Enugu East and Enugu West senatorial zones. More so, there are seventeen (17) local government areas in the state. It is estimated that Enugu state has a population of over 4.4 million people (National Bureau of statistics, 2016).

3.0 Methodology

This study uses a combination of descriptive, correlation and cross-sectional type of research. The study employed the use of a well-structured questionnaire to obtain data. The questionnaires were closed ended using the Likert scale with the respondents. The Likert scale was coded as follows, 1= strongly disagree, 2=Disagree, 3=Neutral, 4=Agree and 5= strongly agree. In Enugu state, the major mobile GSM sector is made up of four (4) operators (MTN, Glo, Airtel and 9 mobile). To this end, this study targets these four telecom operators in Enugu state.

The population of this category of staff mentioned is distributed as follows:

GLO = 15, MTN = 20, Airtel = 15, and 9 Mobile = 10. This makes it a total of 60 senior staff.

A sample size is the number of elements selected from the population which is representative of that population (i.e., a sample must be a representative of the whole population). A representative sample size with known confidence and risk levels was selected based on the work of Yamane (1967).

$$n = \frac{N}{1 + N(e)^2} \qquad (3.1)$$

Where:

n = sample size

N = population size

e = the level of precision

1 = Constant

This formula assumes a degree of variability (i.e., proportion) of 0.05, the level of precision of 5% and a confidence level of 95%.

Based on this, the sample size has been calculated to be 52 respondents.

The Bouley's proportional allocation formula was used in this study to select a sample of the proportion in proportion the population of the company. The formula is stated in equation (2) below.

$$n_b = \frac{n(h)}{N} \qquad (3.2)$$

Where

n_b = Sample proportion allocated to a given group

n =Total sample size

h= Population of a specific group

N = Population of the study

Thus, the sample proportion of each of the companies is as follows;

S/N	Mobile Network Operator	Proportion Allocation
1	Globalcom	13
2	MTN Nigeria	17
3	Airtel Nigeria	13
4	9 Mobile	9
	Total	52

To establish validity, the instrument was given to two examination and evaluation experts to evaluate the relevance of each item in the instrument to the objectives. Content Validity Index of at least 0.7 is to be declared reasonably content valid (Amin, 2005 cited in Siame, 2018). Validity was determined using Content Validity Index (C.V.I). C.V.I = Items rated 3 or 4 by both judges divided by the total number of items in the questionnaire.

$$C.V.I = \frac{\gamma}{N} \qquad (3.3)$$

Where

$\gamma =$ Number of items rated 3 or 4

N = Total number of items

The experts rated the items on the scale; very relevant = 4, quite relevant = 3, somewhat relevant = 2 and not relevant = 1. 28 items in the instrument out of 31 were declared very and quite relevant implying that validity of 0.9 was arrived at, hence the instrument was valid.

The internal precision of the instrument was analysed by evaluating the consistency of the data it generated using Cronbach Alpha. It is worthwhile to point out that the internal consistency reliability test otherwise known as pilot test was conducted using Cronbach Alpha by administering six (6) questionnaires to experts. The overall Cronbach Alpha correlation for the study's instrument of data collection was 0.93. In the same vein, all other variables for the study were adjudged valid, reliable and dependable to the end that the overall reliability index is high.

With the help of the IBM.SPSS version 20, and Excel with Microsoft 365 MSO (Version 2304 Build 16.0.16327.20200, the data collected generated clear themes that were analysed by use of descriptive statistics. The mean, and standard deviations were used to test distribution of the results. Inferential statistics were done including ordinal regressions and nonparametric correlation. These were used to establish the relationship that existed between the independent variables and dependent variable. Qualitative data was then presented using content analysis guided by the study objectives.

Data Presentation, Analysis and Interpretation

4.1 Data Presentation

4.1.1 Data Presentation on Research Question One

What is the relationship between equipment co-location and network infrastructure sharing by telecom operators in Enugu state?

Table 4.1 *Data from survey on Research Question one*

S/N	Question	Mobile Network Operators			
		MTN	**Globalcom**	**Airtel NG**	**9 - Mobile**
i	Do you colocate your equipment and share your infrastructures in Enugu state?	Yes	Yes	Yes	Yes
ii	Which of the Co-location Service Providers (CSP) do you co-locate your infrastructure with?	ATC Nigeria Wireless Infrastructure limited, HIS Towers.	None	ATC, IHS	ATC, IHS
iii	Which of the network operators do you share your infrastructure with in Enugu state?	Airtel, and 9-Mobile	9-Mobile	MTN, 9-Mobile	MTN, Airtel, Globalcom
iv	What other infrastructures do you share with other operators?	Right of way, masts, poles, trenches, space in buildings, Electric Power, antenna mast and tower structure.	Frequencies, Dark fibre, Switching centres, Right of way, masts, poles, trenches, space in buildings, Electric Power, antenna mast and tower structure.	Dark fibre, Switching centres, Right of way, masts, poles, trenches, space in buildings, Electric Power, antenna mast and tower structure.	Frequencies, Dark fibre, Switching centres, Right of way, masts, poles, trenches, space in buildings, Electric Power, antenna mast and tower structure.
v	Do you collocate because it is beneficial to you or simply because it is a regulatory requirement?	For both reasons	For both reasons	It is beneficial	For both reasons

4.1.2 Data Presentation on Research Question Two

What is the effect of cost of network infrastructure rollout on capacity expansion by telecom operators in Enugu state?

Table 4.2 *Data from survey conducted on Research Question Two*

S/N	Item	SD	D	U	A	SA	Total
i	Co-location and Infrastructure Sharing results in low set up cost	0	0	0	32	20	52
ii	Co-location and Infrastructure Sharing results in low operational cost	0	0	4	27	21	52
iii	Capital saved through Co-location and Infrastructure Sharing has been used to introduce innovative products	0	6	3	24	19	52
iv	Co-location and Infrastructure Sharing drives the tariff pricing down and thus increases average revenue per user (ARPU)	5	6	0	30	11	52
v	Revenue is earned faster when infrastructures are collocated and shared	2	6	2	7	35	52
vi	Co-location and Infrastructure Sharing enables better return on asset	3	4	0	18	27	52
vii	Co-location and Infrastructure Sharing saves CAPEX for the operators	0	0	0	15	37	52

SD = strongly disagree, D = Disagree, U = **Undecided, A = Agree, SA = Strongly agree**

4.1.3 Data Presentation on Research Question Three

What is the effect of equipment co-location and infrastructure sharing on the efficiency of mobile network operators in Enugu state Nigeria?

Table 4.3 *Data from Survey on Research Question Three*

S/N	Item	SD	D	U	A	SA	Total
i	Co-location and Infrastructure Sharing results in fast deployment of infrastructures	0	4	2	14	32	52
ii	Co-location and Infrastructure Sharing helps to achieve wider area coverage	0	0	0	0	52	52
iii	Co-location and Infrastructure Sharing results in faster roll out time	0	0	1	13	38	52
iv	Co-location and Infrastructure Sharing reduces the number of site visit	4	10	0	8	30	52
v	Co-location and Infrastructure Sharing improves network capacity and protection	9	12	4	8	19	52
vi	Co-location and Infrastructure Sharing results in efficient use of fixed and scarce resources (land, spectrum)	0	0	0	0	52	52

SD = Strongly disagree, D = Disagree, U = **Undecided, A = Agree, SA = Strongly agree**

4.2 Data Analysis

In this section, the data presented in the previous section (section 4.1) are analysed quantitatively. The analysis was conducted using Microsoft Office Excel. The major focus of the analysis is on the mean and standard deviation of the data as can be seen from Table 4.4 and Table 4.5 below.

Table 4.4 *Descriptive analysis of data on research question two*

S/N	RESEARCH QUESTION TWO	Mean	SD
	What is the effect of cost of network infrastructure rollout on capacity expansion by telecom operators in Enugu state		
i	Co-location and infrastructure sharing results in low set up cost	4.38	0.49
ii	Co-location and infrastructure sharing results in low operational cost	4.33	0.61
iii	Capital saved through Co-location and Infrastructure Sharing has been used to introduce innovative products	4.08	0.94
iv	Co-location and Infrastructure Sharing drives the tariff pricing down and thus increases average revenue per user (ARPU)	3.69	1.20
v	Revenue is earned faster when infrastructures are collocated and shared	4.29	1.20
vi	Co-location and Infrastructure Sharing enables better return on asset	4.19	1.14
vii	Co-location and Infrastructure Sharing saves CAPEX for the operators	4.71	0.45
	AVERAGE MEAN / SD	4.24	0.90

Table 4.5 *Descriptive analysis of data on research question three*

RESEARCH QUESTION THREE:

What is the effect of equipment co-location and infrastructure sharing on the efficiency of mobile network operators in Enugu state Nigeria?

S/N	ANSWER TO RESEARCH QUESTION	Mean	SD
i	Co-location and Infrastructure Sharing results in fast deployment of infrastructures	4.42	0.88
ii	Co-location and Infrastructure Sharing helps to achieve wider area coverage	5.00	0.00
iii	Co-location and Infrastructure Sharing results in faster roll out time	4.71	0.49
iv	Co-location and Infrastructure Sharing reduces the number of site visit	3.96	1.43
v	Co-location and Infrastructure Sharing improves network capacity and protection	3.31	1.56
vi	Co-location and Infrastructure Sharing results in efficient use of fixed and scarce resources (land, spectrum)	5.00	0.00
	AVERAGE MEAN / SD	4.40	0.73

4.3 Test of Hypothesis

4.3.1 Test of H_{o1} using Chi-square test

Table 4.6. *Summary of Responses on Research Question two*

S/N	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Total
i	0	0	0	32	20	52
ii	0	0	4	27	21	52
iii	0	6	3	24	19	52
iv	5	6	0	30	11	52
v	2	6	2	7	35	52
vi	3	4	0	18	27	52
vii	0	0	0	15	37	52
No of Responses	10	22	9	153	170	364
AVERAGE	**1.428571**	**3.142857**	**1.285714**	**21.85714**	**24.28571**	**52**

Table 4.7. *Chi-square test result of* H_{01}

	Observed frequency (O)	**Expected Outcome (E)**	$\boldsymbol{O-E}$	$\boldsymbol{(O-E)^2}$	$\frac{(O-E)^2}{E}$
Strongly Agree	24.3	10.4	13.9	193.21	18.577885
Agree	21.9	10.4	11.5	132.25	12.716346
Undecided	1.3	10.4	-9.1	82.81	7.9625
Agree	3.1	10.4	-7.3	53.29	5.1240385
Strongly Disagree	1.4	10.4	-9	81	7.7884615
$\boldsymbol{X^2}$					**52.169231**

Table 4.8 *Summary of Responses on Research Question three*

S/N	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Total
i	0	4	2	14	32	52
ii	0	0	0	0	52	52
iii	0	0	1	13	38	52
iv	4	10	0	8	30	52
v	9	12	4	8	19	52
vi	0	0	0	0	52	52
No of Responses	13	26	7	43	223	312
AVERAGE	2.166667	4.333333	1.166667	7.166667	37.16667	52

Table 4.9 *Chi-square test result of* H_{02}

	Observed frequency (O)	**Expected Outcome (E)**	$\boldsymbol{O-E}$	$\boldsymbol{(O-E)^2}$	$\frac{(O-E)^2}{E}$
Strongly Agree	37.2	10.4	26.8	718.24	69.061538
Agree	7.2	10.4	-3.2	10.24	0.9846154
Undecided	1.2	10.4	-9.2	84.64	8.1384615
Agree	4.3	10.4	-6.1	37.21	3.5778846
Strongly Disagree	2.2	10.4	-8.2	67.24	6.4653846
$\boldsymbol{X^2}$					**88.227885**

Discussion of Findings

It is evident from table 4.1 that the four mobile network operators (MNOs) under study have imbibed the idea of equipment co-location and infrastructure sharing. The MNOs in accordance with the Nigerian Communications Commission (NCC)'s guideline on infrastructure sharing and equipment co-location (2021) have accepted to share their infrastructures and collocate their equipment. From the result presented in table 4.1, it can be observed that MTN Nigeria, Airtel, and 9-Mobile have contracted some co-location service providers to manage their base

stations. It is also observable from the result that Globalcom are yet to contract any co-location service providers for management of their infrastructures and equipment. Beside the fact that the regulatory body the NCC requires that the MNOs co-locate their equipment and share their infrastructures, the MNOs believe that infrastructure sharing and equipment co-location are beneficial to their businesses. This revelation by MNOs in Enugu state is in tandem with the findings of Adenkitan (2019) who asserted that MNOs in Benue state have benefited much form sharing their infrastructures.

Similarly, it is evident from the result presented in table 4.4 that equipment co-location and infrastructure sharing by MNOs in Enugu state has significantly resulted in minimization of cost of infrastructure rollout and capacity expansion of the operators. The firms under study have shown that co-location and infrastructure sharing result in low cost set up, low operational cost, boost introduction of innovative products through money saved, increase in average revenue per user, fast generation of revenue, and increased return on asset. The quantitative analysis of the data as presented in table 4.4 shows that the average mean of the responses is 4.24 out of possible 5.0 with a standard deviation of 0.90. This is a testament to the fact that the MNOs nearly strongly agrees that equipment co-location and infrastructure sharing has been instrumental in cost minimization and enhancement of capacity expansion. In furtherance, the test of the first null hypothesis as presented in table 4.7 above shows a test statistic value of 52.17 against the critical value of 9.49. Thus, the null hypothesis which states that equipment co-location and network infrastructure sharing do not result in a significant reduction in cost of network infrastructure rollout and capacity expansions for telecoms operators in Nigeria is rejected while the alternate hypothesis is accepted. This result further confirms the study carried out by Dawodu and Osondu (2019).

Finally, the quantitative analysis presented in Table 4.5 clearly shows that equipment co-location and infrastructure sharing by MNOs in Enugu state Nigeria has significantly enhanced the efficiency of MNOs in the state. According to the data as evident in Table 4.5, equipment co-location and infrastructure sharing lead to fast deployment of infrastructure, helps to achieve wider coverage, results in faster roll out time, reduce number of site visitation, improve network capacity and protection and encourage efficient use of scarce resources such as land and spectrum. The average mean response of 4.40 with a standard deviation of 0.73 is a clear testament to the fat the MNOs nearly strongly agree that equipment co-location and infrastructure sharing enhance their efficiency. This finding was confirmed further through the test of the second null hypothesis as shown in Table 4.9. The Chi-square test resulted in a test statistic of 88.23 against the table (critical value) of 9.49 at 95% confidence level. This high value implies that the second null hypothesis which states that the equipment co-location and network infrastructure sharing do not result in an improved efficiency in the utilization of telecoms infrastructure for telecom operators in Enugu state Nigeria is false and, thus, rejected. The implication is that the alternate hypothesis is therefore accepted. This result agrees with the study carried out by Faz (2020).

5.1 Summary of Findings

1. The four MNOs (MTN, Airtel, Globalcom, and 9-Mobile) under study engage in passive sharing among themselves. While MTN, Airtel, and 9-Mobile have contracted out some of their base transceiver stations to co-location service providers (IHS, and ATC), Globalcom solely manage their base transceiver stations. It is imperative to point out the confirmation of the MNOs that they venture into co-location not only because it is a regulatory requirement, but also it enhances their businesses.
2. Active sharing by MNOs in Enugu state has positively effect on the capacity expansion of mobile network operators in Enugu state Nigeria. This finding was arrived at through a detailed quantitative analysis which showed that the average mean of the respondents to the questionnaire was 4.24 out of possible 5.0 with a

standard deviation of 0.90. The implication of this is that the MNOs nearly strongly agree that engaging equipment co-location and infrastructure sharing reduces the huge cost burden on them.

3.Spectrum sharing bring about improvement in the efficiency of the MNOs. This finding was made through data analysis which revealed that the average mean response of the MNOs is 4.40 out of possible 5.0 with a standard deviation of 0.73. In other words, the respondents almost strongly agree that the efficiency of the operation has been significantly enhanced through equipment co-location and infrastructure sharing.

5.2 Conclusion

This study focused on the impact of equipment co-location and enrapture sharing on the performance of mobile network operators in Enugu state Nigeria. It is on record that telecommunication revolution has so far remained one of the most gains of the nascent century as many other developments owe their evolution to the telecommunication revolution. Against this backdrop, this study examined a critical development in operation of telecommunication infrastructures which are equipment co-location and infrastructure sharing. This study confirms that this innovation has indeed helped MNOs to improve their services and deepen their penetration at a reduced cost.

5.3 Recommendations

In view of the findings of this study, it is recommended that:

1. The Nigerian Communications Commission (NCC) should further review their guidelines on equipment co-location and infrastructure sharing to address the concerns that has made the MNOs to be too circumspect in embracing the policy.
2. The MNOs especially Globalcom should endeavour to contract out their base transceiver stations (BTS) to co-location service providers in view of the gains therein.
3. The MNOs should endeavour to leverage on equipment co-location and infrastructure sharing to deepen their penetration in rural areas of the state.

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