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Game Theoretic Analysis of the Competition among Global System for Mobile Communications (GSM) Firms in Nigeria

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Abstract:
The study critically examines how the Global System for Mobile Communication (GSM) firms determine the optimal strategy from television and radio advertisements given that each firm seeks to gain the largest market share. The methodology used involved a Game Theoretic approach and linear programming. The result of the analysis showed that for MTN to maintain its position as the leader in the industry, it should invest 0% of its M billion Naira in Television Advertisement and 100% in Radio Advertisement when competing with Airtel, Globacom and Etisalat. This will yield a pay-off of This will yield a pay-off of N9M billion. Findings also revealed that for Globacom to gain the largest market share in the industry, it should invest 0% of her ₦N in Television Advertisement and 100% in Radio Advertisement when competing with MTN. This will produce a benefit of 9N billion Naira. The results also showed the optimal resource allocations for Airtel and Globacom for each firm to gain the largest market share in the industry when competing with MTN. Findings also revealed the pay-offs for both firms when they compete with MTN. It is therefore recommended that Nigerian GSM firms use Game Theory in optimizing resource allocation between strategies.

Keywords: *Telecommunications, GSM, Game Theoretic Analysis, Prisoner's Dilemma*

1. Introduction

The Telecommunications industry is undoubtedly a critical and strategic industry for any economy that desires to achieve economic growth; this is because of its positive contribution to the outputs growth of other sectors. Telecommunication services are required for the smooth running of every firm in every industry. The sector also attracts foreign direct investment, thereby opening up the domestic economy to the global market. Although, the first use of telecommunication involved the use of a cable connection between the colonial office in London and Lagos in 1886, telephone services were later provided to government officials in 1893 and further later extended to Ilorin and Jebba. Also, a three channel line carrier system between Lagos and Ibadan was commissioned and later extended to Benin, Kano, Enugu, Kaduna and Osogbo, between 1946 – 1952, (Ajayi, 1999).

Article 1.3 of the International Telecommunication Union's (ITU) Radio Regulations (RR) defines Telecommunication as any transmission, emission or reception of signs, signals, writings, images and sounds or intelligence of any nature by wire, radio, optical or other electromagnetic systems. It involves the exchange of information between two or more entities through the use of technology. Telecommunication transmits information as electrical signals or electromagnetic waves through physical channels such as signal cables. Modern technologies used in telecommunication include electrical and electromagnetic technologies, such as telegraph, telephone, networks, radio, microwave transmission, fiber optics, and communications satellites. Telecommunications usually takes the form of wired and wireless types.

Until 1985, the institutions in the Telecommunications Industry were the Department of Posts and Telecommunications and the Nigerian External Telecommunications (NET). While the former was responsible for internal network, the latter revolved around external network. However, in 1985, the Department of Posts and Telecommunications witnessed a separation into the Postal and Telecommunications[1] sections. NITEL was established to provide telecommunication services for individuals and organizations in the country. In 1993, NITEL introduced services such as voice mail, trunk radio, paging system and phone card, in addition, services such as electronic mail, telefax and video telephone were included.

Nevertheless, NITEL was characterized with several anomalies (mismanagement, corruption, poor service delivery and unreliably cost of telephone services). Hence, there was an urgent need to remedy the deplorable state of the telecommunications sector; this led to the establishment of the National Communication Commission[2] (NCC) by the Federal Government in 1992, under Decree Number 75. It has the responsibility of providing an enabling environment for firms, promoting efficient service delivery in the industry and the implementation of the national communications or telecommunications policy as may be regularly modified and amended. It also protects the rights and interest of service providers and consumers within Nigeria.

In 1999, the priority of the government was majorly to dissolve the monopoly of the sector. The privatization of the sector gave room for private sector participation as such fostered competition (Hassan, 2011); also, NITEL was stripped of its monopoly power in the market to encourage competition while the liberalization of the sector enabled foreign investors to participate. This led to the grant of operating licenses to 3 GSM firms[3] in 2001. Until Globacom Nigeria entered the market, customers were not charged on a per second basis. The introduction of per second billing system spurred a healthy competition; this has helped to improve the quality of services available to subscribers. Etisalat, the most recent GSM network provider commenced operations in 2008 introducing numerous mouthwatering packages to swipe away customers from their competitors, hence, spurring other GSM operators ensuring improvement in their packages and services.

The liberalization of the telecommunications sector has led to more players participating in the industry culminating to more foreign investments, improved infrastructure, job opportunities, and increased output in other sectors, (Awoleye et al, 2012). Hence, it contributes significantly to the country's Gross Domestic Product(GDP). The bar Chart *Figure 1* highlights the contribution of the telecommunications industry toNigeria's GDP from 2010 to 2015:

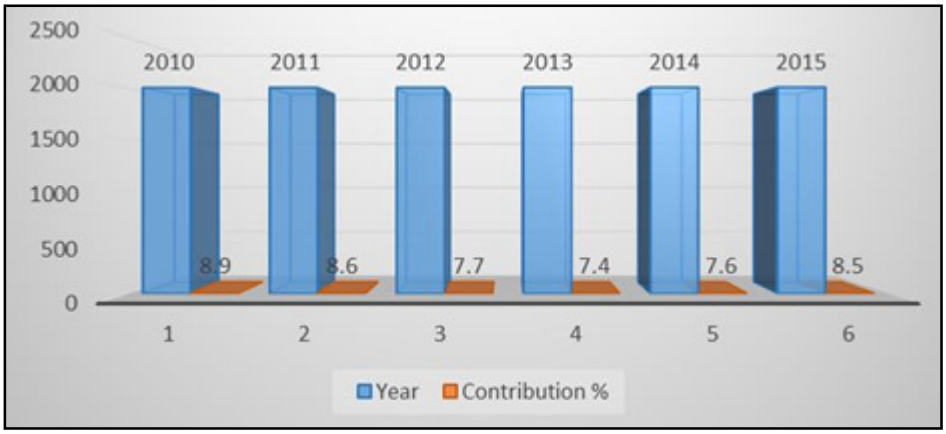

Figure 1: Contribution of the Telecommunications Industry to Nigeria's GDP
2016 NCC (Nigerian Communications Commission) Contribution of Telecoms Industry to GDP

Liberalization can be identified as the arrowhead to improvement of the telecommunications infrastructure (these include network roll outs, upgrades, construction of core networks, transmission networks, power supply networks and expansion) at several parts of the nation. The resultant effect of the transformation in the telecommunications sector on other sectors (such as banking, education and health) in terms of the quality of their services are evident E.g., distance learning, mobile banking and e-health, (Ndukwe, 2005). Liberalization has bridged the social, economic and political gaps between the urban and rural dwellers, thus reducing the urban-rural inequality (Ijewere and Gbandi, 2012).

The telecommunications sector reform has led to product innovation and improvement of services with the use of GSM, CDMA (Code Division Multiple Access), VoIP (Voice over Internet Protocol) and Fixed (Wired and Wireless) technologies. However, the GSM is the most dominant technology in the Nigerian Telecommunications Industry. This accounts for the increase in the number of GSM subscribers from a meager 400,000 before 2001 to a staggering 147 million customers in 2016. The CDMA, VoIP, Fixed (Wired and Wireless) control a small percentage of the market share in the Nigerian telecommunications industry. This is shown in the pie Chart in the *Figure 2*:

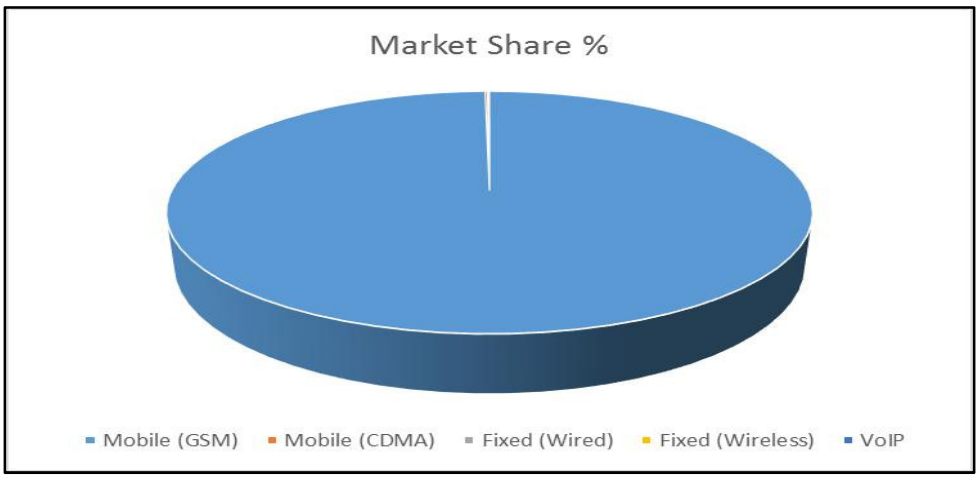

Figure 2: Market Share in terms of Technology in the Telecommunications Industry
November 2016 NCC (Nigerian Communications Commission) Market Share by Technology Report

The liberalization led to the entrant of more viable firms into the industry, more firms induces a competitive Telecommunications market[4]. Currently, there are 4 GSM operators in the telecommunications industry of the nation. Consequently, the market structure of Nigeria's GSM industry is oligopolistic in nature. The GSM industry in Nigeria has been characterized by stiff competition during the last decade. This is reflected in the market share controlled by each competitor. The pie Chart below illustrates this:

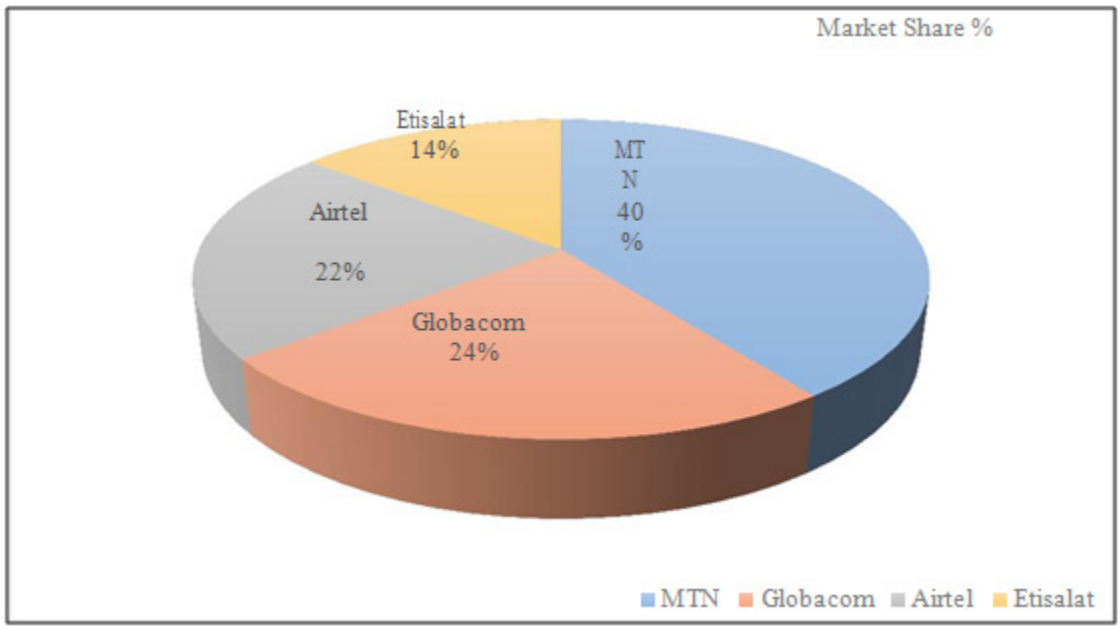

Figure 3: Market Share of GSM Firms
November 2016 Nigerian Communications Commission (NCC) Market Share by Operator (GSM) Report

Several studies have been conducted by employing several tools such as Game Theory, Linear Programming, Capital Budgeting Algorithm, Monte Carlo Simulation (Achugamonu, Inyama and Onuoha (2012), (Araujo, (2012)). Studies have revealed that the competitive behaviour of GSM operators can be analysed using Game Theory with the aim of ensuring efficient resource allocation with optimal benefits. Game Theory is used to examine the strategies employed by firms in achieving their goals (e.g., profit maximization, increase in market share etc.). Most times, GSM firms compete against each other using a combination of strategies in a bid to stay ahead of their competitors. Some of such strategies include mobile internet services, free airtime and provision of latest information on diverse areas of specialization.

However, research reveals that the concept of Game Theory has not been used extensively in the study of industries in developing economies. Thus there is the need to apply more of this concept to the analysis of one of the industries in Nigeria, a developing country. Even where Game Theory has been applied to the research of the telecommunications industry of Nigeria, it has been limited to two of the firms that respectively control 42% and 22% of the GSM market share (NCC January 2016 Subscriber Statistics Report). This has given rise to the need to apply the concept of Game Theory to the study of the relationship between the accomplishment of company goals by all the GSM firms and the strategies used.

The challenge often faced by GSM firms in Nigeria is the choice of the best strategies that yields optimal result, the efficiency of the resource allocation between the strategies is a function of the benefits from each strategy. Some of the strategies available to GSM operating firms includes: advertising, service promotion, provision of internet services and Mobile Number Portability[5] (MNP).

Suppose two GSM operating firms A and B have Mbillion Naira" and "N billion Naira respectively. The financial resources are available for television advertisement and radio advertisement as the strategies to be adopted. We are faced with three critical questions: How will each firm determine the optimal strategy from television advertisement and radio advertisement, assuming that each firm wants to gain the largest market share? What will be the pay-off from the optimal strategy chosen by each firm? How will each firm allocate their resources between television advertisement and radio advertisement to achieve optimal benefits? This paper focuses on the competitions between MTN and Globacom, MTN and Airtel and MTN and Etisalat.

2.1. Theoretical Background and Literature Review

Game Theory often referred to as the Science of Strategy explains how players make decisions in conflicts or competition. It was initially applied to examine the economic behavior of firms, markets and consumers. It has been widely applied to the behaviour of producers with few competitors. Game Theory enables firms to make appropriate choices and helps in understanding or predicting the behaviour of competitors. Modern game theory was introduced with the publication of the book 'Theory of Games and Economic Behaviour' authored by Morgenstern and Von Neumann (1953). Morgenstern and Von Neumann examined cooperative games involving various players in their book. It was later applied to other areas of specialization aside from Economics to social network formation, ethical behaviour, biology and other fields of specialization.

A game can be described as the mathematical representation of conflicts in which the players involved get results. It was originated by Antoine Augustine Cournot in 1838. The agents involved are usually called players (individuals or firms). Some of the components of a game include rules, pay-offs and strategies. Rules govern the conduct of the players; they are an important source of power in games. Strategies are courses of action taken to achieve the goals of the players. They influence the decision making process. In applying Game Theory to the competitive behaviour of firms, firms face a number of strategic decisions which can be taken to realize a desired pay-off. A pay-off is the outcome of adopting a strategy such as win, lose or draw often represented by a Pay-off Matrix. Firms can derive a range of pay-offs from the strategies they use. Such pay-offs can include greater profit for shareholders, increase in market share, improved chances of survival and eliminating a rival.

A game can be either Static or Dynamic. Static games involve players taking their decisions, without the knowledge of the actions of their competitors. Actions do not have to be taken at the same time, but rather it is as if the decisions are made simultaneously. Thus, the element of time is excluded from these kinds of games.

Static games are described in strategic forms. The Prisoner's Dilemma is an example of a static game wherein two suspects are arrested for a crime and are interrogated in separate cells. One of the suspects will be set free and the other will be imprisoned, if the first confesses and the other refuses to own up. If neither owns up, both of them will receive a lower punishment, than if they both confess. Each suspect is afraid the other will confess and thus is quick to confess to be released. In Dynamic games often represented in extensive forms, the players are able to know the actions of competitors before making their move. Dynamic games can be repeated a number of times. This enables the competitors to know and work with the result of previous rounds.

Oligopoly can be defined as a market model of the imperfect competition type, with the existence of only a few companies in a sector or industry, each offering a product similar to the others. Many models of oligopoly exist. They are found through the study of oligopolistic structures. These models differ from each other mostly in the nature of the competitive behaviour of the companies. Some models describe only the behaviour of two companies in the studied market (duopoly). The firms can choose to corporate or compete. When competing, firms in a duopolistic market usually resort to non-price competition to achieve corporate goals such as profit-maximization and increase in market share. The firms may have information about the decisions of their rival. This influences the strategies they adopt in achieving their goals. Others describe several companies with the same level of power (cartel). Others also assume that one of the companies has a dominant position in the market.

Several projects have been conducted in the area of Game Theory. Different methodologies have also been employed on such studies. Araujo (2012) conducted a research on capital budgeting under competitive markets in the telecommunications industry in Portugal. The study focused on the economic feasibility of Fiber-to-the-Home networks using latest techniques. The methodological approach included the use of Game Theory, capital budgeting algorithms with real options and Monte Carlo simulations. These were adopted to analyse project risk. Results showed that with the use of Game Theory, Capital Budgeting Algorithm and Monte Carlo Simulation, firms in the telecommunications industry can evaluate the economic potential of their projected networks.

Guldmann and Kucukmehmetoglu (2002) analysed water resource issues with Game Theory taking Tigris and Euphrates rivers as a case study. They adopted a linear programming model that allocated water resources among agricultural and urban uses of Turkey, Syria, and Iraq. Cooperative game theory concepts such as Core and Shapley value were used to determine stable water allocations.

Gkonis and Psaraftis (2007) adopted a Game Theoretic approach to the analysis of the investment rules and competitive patterns in LNG (Liquefied Natural Gas) shipping market. The research revealed some useful insights. It demonstrated that it is important to consider the reaction of other players when making a decision. It also revealed that it is critical to gain information about the types of competitors in a game.

Fernandez (2008) applied the concept of Game Theory to examining the sharing of penalties and rewards in projects. The paper examines how to divide the total reward and penalty among project activities. A game theoretic approach is used to determine a set of stable allocations of the total penalty and reward. Findings showed that the total reward for the project does not need to be equal to the summation of the rewards for the subprojects.

Mattos, Vieira, Schmitz, and Alencar (2014) used Game Theory to analyse incremental funding method in Software projects. The Incremental Funding Method (IFM) is a popular technique for maximizing the financial return of software projects in a monopolistic market structure. Gambit, a tool for solving finite games, was used in determining all Nash equilibria. The findings of the research demonstrated that in a competitive market the equilibrium solutions enable competitors to choose the optimal monopolistic implementation order.

Serghini (2003) analyses water resource issues in multipurpose dam projects in Morocco through a Game Theoretic approach. He adopted the methodology of the FDC (Fully Distributed Costs) allocation rules, and applied it with the Shapley value and the Nucleolus. The multipurpose use of water in Morocco includes hydroelectric power, irrigation, and urban supply. There are usually conflicts over tariffs between the ministries that manage the entire infrastructure. The author examined two methods for allocating the costs: the FDC methods and the main apportioning methods.

Achugamonu, Inyama and Onuoha (2012) examined the objective project optimization for the Nigerian Telecommunications Sector with the use of Game Theory. MTN Nigeria and Globacom Nigeria were used as the case studies. Primary and Secondary data were used for the investigation. The methodology employed was linear programming. Findings showed that competitors in the Nigerian telecommunications industry should employ Game Theory in taking actions for optimal results in achieving company objectives. It was recommended that MTN Nigeria and Globacom Nigeria use the results of the study in allocating resources and planning to ensure better results.

Oziegbe (2011) applied the concept of Game Theory to examining business strategy in undeveloped countries adopting Nigeria as a case study. The methodology employed was a strategic form of a game. Results showed that game theory is an essential tool for examining the strategies of managers when determined by the actions of a competitor.

Lippai and Heaney (2000) applied Game Theory to present a method for determining efficient and equitable impact fees for urban water systems for each user, based on the type of demand on the system. The study assessed the significance of assuring a fair assessment of impact fees for an urban water supply system. The methodology used was cooperative game theory allocation solutions. The conclusion of the research was that the cost of the project needs to be equitably allocated among all existing and new users.

Fudenberg and Levine (1988) applied the concept of Game Theory to open-loop and closed-loop equilibria in dynamic games in the case of many players. Nonatomic games in which the pay-off of a player is not influenced by the actions of a single rival were examined. The limits of a finite game approaching a nonatomic game were also examined. The objective was to demonstrate that equilibria in the nonatomic game are approximately the same as those in the approaching finite game and that the limit of equilibria is an equilibrium and every sequence of equilibria has a limit. Two-period models were adopted for the analysis. Findings showed that as strategic possibilities increase with the game and the set of closed-loop equilibria expands, it becomes more difficult to guarantee that closed-loop equilibria are close to the open-loop equilibria.

Buisman and Wohlin (2003) examined the bidding behaviors of firms for software projects. A game theoretic approach was adopted for the study. The results showed that risks do not pay off and it is difficult to recover from losses.

Villiger (2000) conducted an investigation on traffic control. The methodology adopted for the study involved the use of Game Theory. The results showed an improvement of about 11% and 12% with respect to the total time delay to the existing traffic system when Cournot and Stackelberg models were used.

Hamers, Miquel, Norde, and van Velzen (2003) examined the allocation of maintenance of an irrigation system with the use of Cooperative Game Theory. They introduced fixed tree games with repeated players (FRP games). The results indicated that FRP games are balanced. They also showed that the core of an FRP game coincides with the core of a related concave fixed tree game.

Fernandez (2002) investigated the effects of trade liberalization on transboundary water pollution with the use of a differential game. The U.S.-Mexico border was adopted as the case study. Results showed that trade liberalization causes Mexico to curb pollution in both noncooperative and cooperative games. They also led to the conclusion that trade liberalization provides economic incentives to reduce pollution and reuse treated wastewater for irrigation.

Just and Netanyahu (2004) applied an interconnected game theory to the study of common pool resources. They used the Mountain Aquifer shared by the Israelis and Palestinians as the case study. Their findings show that by linking issues with reciprocal importance (benefits) to the parties through interconnected games, outcomes that emanate from the „victim pays‟ nature of certain situations can be avoided.

Montero (2005) examined the behavior of competitors when they bargain. The results indicated that altruism may be beneficial in bargaining when there is competition for bargaining partners. The results also indicate that the similar features of preferences that are beneficial in two-player bargaining can be detrimental when competition exists between bargaining partners.

None of the studies conducted on the telecommunications industry have addressed the competition among GSM operating firms in Nigeria.

3. Research Methodology

The study employed secondary data, that is, data on the amount spent on television advertisement and radio advertisement by each GSM firm was collected. Data was sourced from Media Monitoring Services Limited[6], Internet and personal interview. The period of the study covers from June 2014 to June 2015. The Linear Program Solver that is based on the efficient implementation of the modified simplex method was used for the computation of the results. The application is used for solving linear, integer, goal programming problems and for conducting sensitivity analysis.

3.1. Model Specification

Assuming two GSM operating firms A and B have M billion Naira" and "N billion Naira respectively for adopting television advertisement and radio advertisement as strategies. The Solution for firm A is represented by the following Linear Program Problem:

Maximize $\sum_{j=1}^{n} cjxj$

Subject to $\sum_{j=1}^{n} aijxj \leq$ bi, i = 1, 2,…… m

$xj \geq 0$, j = 1, 2, …….. n

Where xj represents the strategy

The Solution for firm B is the Dual of the Solution for firm A. This is represented by the following Linear Program Problem:

Minimize $\sum_{i=1}^{m} biyi$

Subject to $\sum_{i=1}^{m} yiaij \geq cj$, j = 1, 2,……..n

$y_i \geq 0$, i = 1, 2, ……..m

Where, yi represents the strategy

The competition between Nigerian GSM firms can be analysed through the prisoner's dilemma game. Nigerian GSM companies produce products and services that are functionally the same. They can either cooperate or compete. If they both cooperate, they can charge monopoly prices; this would translate to having the same market share. However, they usually choose to compete, this is due to the fact that a critical goal of each firm is to maximize market share. In a bid to achieve this, each firm reduces the price of their product to achieve a higher market share. Examples of this strategy is GSM operating firms reducing their tariff for making calls and offering low prices for Internet services.

In any Game Theoretical Framework, linear programming algorithm has been found to be an effective tool in finding the optimal strategy of any firm in a competitive economy. According to Fabayo (2009), Linear Programming is a mathematical optimization technique which is designed to determine the optimal allocation of scarce resources among competing products or activities. The optimal outcome can be maximum profit or minimum cost. Linear programming has been employed to determine advertising budgets to allocate resources to television, radio, billboard and newspaper advertisements.

4. Presentation and Analysis of Results

The objective of this project is to determine the pay-off from television advertisement and radio advertisement for each GSM firm. To achieve this, yearly data on the expenditure on television advertisement and radio advertisement by each firm were collected. The period of data collection was from June 2014 to June 2015. This information is presented in the table in the next page:

Firm	**Expenditure on Television**			**Expenditure on Radio**		
	Advertisement (Billion Naira)			Advertisement (Billion Naira)		
MTN	1.8			0.9		
Globacom	0.7			0.4		
Airtel	1.2			0.4		
Etisalat	1.1			0.5		

Table 1: Firms' Expenditure on Television Advertisement and Radio Advertisement from June 2014 to June 2015
Source: Media Monitoring Services Ltd (MMSL)

Firm	**Expenditure on Television**			**Expenditure on Radio Advertisement**
	Advertisement (Billion Naira)			(Billion Naira)
MTN	18			9
Globacom	7			4
Airtel	12			4
Etisalat	11			5

Table 2: Approximated Total Expenditure on Television Advertisement and Radio Advertisement from June 2014 to June 2015

Tables 1and 2 can be used to describe a two-person duopolistic game. This game can be solved by employing the Simplex Method of Linear Programming and the Linear Program Solver.

4.1. Competition between MTN and Globacom

Let x_1 be the probability representing Television Advertisement and x_2 the probability representing Radio Advertisement. Let the value of the game for MTN be represented by V_M. Using the entries in Table 1 and 2 we formulate the following Linear Programming for MTN Solution.

4.1.1. MTN Solution

Maximize $x_0 = x_1 + x_2$
Subject to $7x_1 + 4x_2 \leq 1$
$18x_1 + 9x_2 \leq 1$
$x_1, x_2 \geq 0$

Solving the Linear Programming Problem with the Simplex Method and the Linear Program Solver, we have:
$x_0 = 1/9$, $x_1 = 0$ and $x_2 = 1/9$
Since we are maximizing $V_M = 1/x_0 = 9$
The required proportions (probability) is
$X_1 = x_1/x_0 = 0 \times 9 = 0$
$X_2 = x_2/x_0 = 1/9 \times 9 = 1$

4.1.2. Globacom Solution

Globacom's minimization problem is the dual of MTN"s maximization problem. Using the Duality Theory, the conversion is as follows.
Let y_1 be the probability representing Television Advertisement. Let y_2 be the probability representing Radio Advertisement and V_G represent the value of the game for Globacom. Using the Duality Theory we have

- Minimize $y_0 = y_1 + y_2$
- Subject to $7y_1 + 18y_2 \geq 1$
- $4y_1 + 9y_2 \geq 1$
- $y_1, y_2 \geq 0$

Solving the Linear Programming Problem with the Simplex Method and Linear Program Solver, we have:

- $y_0 = 1/9$, $y_1 = 0$ and $y_2 = 1/9$
- $V_G = 1/y_0 = 9/1 = 9$

The required proportions (probability) is

- $Y_1 = y_1/y_0 = 0 \times 9 = 0$
- $Y_2 = y_2/y_0 = 1/9 \times 9/1 = 1$

The results show that when competing with Globacom, for MTN to maintain its position as the leader in the Nigerian GSM Industry, it should invest 0% of the M billion Naira funds available to the firm into Television Advertisement and 100% into Radio Advertisement. This will yield a pay-off of M billion Naira. Thus the optimal allocation of resources for MTN is

- Television Advertisement = 0%
- Radio Advertisement = 100%

The findings also show that for Globacom to change the structure of the Nigerian GSM Industry by attaining the position of the leader in the Industry and thus gaining the largest market share, it should allocate 0% of the N billion Naira funds available to the firm into Television Advertisement and 100% into Radio Advertisement. This will produce a pay-off of 9M billion Naira. Thus the optimal allocation of resources for Globacom is

- Television Advertisement = 0%
- Radio Advertisement = 100%

4.2. Competition between MTN and Airtel

Let a_1 be the probability representing Television Advertisement and a_2 the probability representing Radio Advertisement. Let the value of the game for MTN be represented by V_M. Using the entries in Table 1 and 2 we formulate the following Linear Programming for MTN Solution.

4.2.1. MTN Solution

- Maximize $a_0 = a_1 + a_2$
- Subject to $12a_1 + 4a_2 \leq 1$
- $18a_1 + 9a_2 \leq 1$
- $a_1, a_2 \geq 0$

Solving the Linear Programming Problem, we have:

- $a_0 = 1/9$, $a_1 = 0$ and $a_2 = 1/9$

- Since we are maximizing $V_M = 1/a_0 = 9$

The required proportions (probability) is
- $A_1 = a_1/a_0 = 0 \times 9 = 0$
- $A_2 = a_2/a_0 = 1/9 \times 9 = 1$

4.2.2. Airtel Solution

Airtel's minimization problem is the dual of MTN"s maximization problem. Using the Duality Theory, the conversion is as follows. Let b_1 be the probability representing Television Advertisement. Let b_2 be the probability representing Radio Advertisement and V_A represent the value of the game for Airtel. Using the Duality Theory we have

- Minimize $b_0 = b_1 + b_2$
- Subject to $12b_1 + 18b_2 \geq 1$
- $4b_1 + 9b_2 \geq 1$
- $b_1, b_2 \geq 0$

Solving the Linear Programming Problem, we have:
- $b_0 = 1/9$, $b_1 = 0$ and $b_2 = 1/9$
- $V_A = 1/b_0 = 1 \times 9 = 9$

The required proportions (probability) is
- $B_1 = b_1/b_0 = 0 \times 9 = 0$
- $B_2 = b_2/b_0 = 1/9 \times 9 = 1$

The results show that when competing with Airtel, for MTN to maintain its position as the leader in the Industry, it should invest 0% of the M billion Naira funds available to the firm into Television Advertisement and 100% into Radio Advertisement. This will yield a pay-off of M billion Naira. Thus the optimal allocation of resources for MTN is

- Television Advertisement = 0%
- Radio Advertisement = 100%

The findings also show that for Airtel to change the structure of the Industry by attaining the position of the leader and thus acquiring the largest market share, it should allocate 0% of the M billion Naira funds available to the firm into Television Advertisement and 100% into Radio Advertisement. This will produce a pay-off of M billion Naira. Thus the optimal allocation of resources for Airtel is

- Television Advertisement = 0%
- Radio Advertisement = 100%

4.3. Competition between MTN and Etisalat

Let c_1 be the probability representing Television Advertisement and c_2 the probability representing Radio Advertisement. Let the value of the game for MTN be represented by V_M. Using the entries in Table 1 and 4.2 we formulate the following Linear Programming for MTN Solution.

4.3.1. MTN Solution

- Maximize $c_0 = c_1 + c_2$
- Subject to $11c_1 + 5c_2 \leq 1$
- $18c_1 + 9c_2 \leq 1$
- $c_1, c_2 \geq 0$

Solving the Linear Programming Problem with the Simplex Method, we have:
- $c_0 = 1/9$, $c_1 = 0$ and $c_2 = 1/9$
- Since we are maximizing $V_M = 1/c_0 = 9$

The required proportions (probability) is
- $C_1 = c_1/c_0 = 0 \times 9 = 0$
- $C_2 = c_2/c_0 = 1/9 \times 9 = 1$

4.3.2. Etisalat Solution

Etisalat's minimization problem is the dual of MTN's maximization problem. Using the Duality Theory, the conversion is as follows.

Let d_1 be the probability representing Television Advertisement. Let d_2 be the probability representing Radio Advertisement and V_E represent the value of the game for Etisalat. Using the Duality Theory we have

- Minimize $d_0 = d_1 + d_2$
- Subject to $11d_1 + 18d_2 \geq 1$
- $5d_1 + 9d_2 \geq 1$
- $d_1, d_2 \geq 0$

Solving the Linear Programming Problem, we have:

- $d_0 = 1/9$, $d_1 = 0$ and $d_2 = 1/9$
- $V_E = 1/d_0 = 1 \times 9 = 9$

The required proportions (probability) is

- $D_1 = d_1/d_0 = 0 \times 9 = 0$
- $D_2 = d_2/d_0 = 1/9 \times 9 = 1$

The results show that when competing with Etisalat, for MTN to maintain its position as the leader in the Nigerian GSM Industry, it should invest 0% of the M billion Naira funds available to the firm into Television Advertisement and 100% into Radio Advertisement. This will yield a pay-off of 9M billion Naira. Thus the optimal allocation of resources for MTN is

- Television Advertisement = 0%
- Radio Advertisement = 100%

The study also showed that for Etisalat to attain the position of the leader in the Industry and thus gain the largest market share, it should allocate 0% of the K billion Naira funds available to the firm into Television Advertisement and 100% into Radio Advertisement. This will produce a pay-off of 9K billion Naira. Thus the optimal allocation of resources for Etisalat is

- Television Advertisement = 0%
- Radio Advertisement = 100%

5. Conclusion and Recommendations

Game Theory can be a significant tool for GSM firms for optimizing resource allocation between strategies. Firms usually face the challenge of deciding on the best allocation of scarce resources on competing needs in a bid to gain the largest market share. An inefficient allocation of resources leads to waste and incurring losses. This can be prevented by adopting a Game Theoretic approach. Game Theory enables firms to optimize the allocation of limited resources among various strategies in gaining the largest market share. It also enables firms to derive the allocation of resources that will yield an optimal benefit.

Nigerian GSM firms can determine the pay-off from the strategies available to them with the use of Game Theory. Such organizations are often concerned about the pay-off from their actions. They intend to know the benefits obtainable from their strategies before committing resources to such decision. This enables them to determine whether their strategies are profitable or inefficient. This is possible with the use of Game Theory. Game Theory can serve as a tool for determining the pay-off from the strategies firms are considering in acquiring the largest market share. Thus Game Theory can enable firms to evaluate the effectiveness of the strategies available to them.

Based on the results of this research, it is recommended as follows:

1. GSM firms should employ Game Theory in determining the optimal strategy from television advertisement and radio advertisement in gaining the largest market share.
2. GSM firms should use Game Theory in determining the pay-off from the optimal strategies they adopt.
3. GSM firms should employ Game Theory in optimizing resource allocation between television advertisement and radio advertisement.
4. GSM firms in the Nigerian Telecommunications Industry should consider the strategies of their competitors in determining the best decision to adopt.

6. End Note

1. Telecommunications arm was merged with NET to form the Nigerian Telecommunications Limited (NITEL).
2. The National Communication Commission is the national authority that regulates the activities of operators in the telecommunications industry.
3. The firms were Econet, MTN and MTEL. The first GSM operating firm, Econet (now Airtel) started operations in August, 2001, after which MTN Nigeria commenced business. Globacom Nigeria was the third GSM network provider to join the market in 2003 after obtaining its license in 2002.

4. The competition among the GSM operators in the telecommunications industry can be viewed as a game
5. Mobile Number Portability means that a customer of MTN can patronize Globacom's services and still retain his MTN mobile line.
6. Media Monitoring Services Limited is a firm that specializes in gathering information on the expenditure of firms on various forms of advertising

7. References

i. Achugamonu, P. C., Inyama, S. C., &Onuoha, D. C. (2012). Application of Game Theory in Objective Project Optimization for Nigerian Telecommunication Industry. West African Journal of Industrial and AcademicResearch, 2(1), 62-69.
ii. Ajayi, G. O., Salawu, R. I., &Raji, T. I. (1999). A Century of Telecommunications in Nigeria- What Next? in Noam, Eli (ed) Telecommunications in Africa. United Kingdom: Oxford University Press pp: 163-179.
iii. Araujo, M. (2012). Economics of Telecommunications: Capital Budgeting under Competitive Markets usingStrategic Game Theory and Real Options Approach. School of Economics, University of Porto, Portugal.
iv. Awoleye, O. M., Okogun, O. A., Ojuloge, B. A., Atoyebi, M. K., &Ojo, B. F. (2012). Socio-Economic of Telecommunication Growth in Nigeria in Nigeria: An Exploratory Study Interdisciplinary. Journal ofContemporary Research in Business, 4(2), 256- 262.
v. Buisman, J., &Wohlin, C. (2003). Using Game Theory to Study Bidding for Software Projects. Proceedings EASE: Empirical Assessment and Evaluation in Software Engineering, Keele, UK, 2003.
vi. Economics Online (2015). Oligopoly. Retrieved from www.economicsonline.co.uk/Business_economics/Oligopoly.html
vii. Fabayo, J. A. (2009). Quantitative Techniques for Economic and Management Decisions, 2nd Edition Ibadan: Intec Printers LTD.
viii. Fernandez, E. A. (2008). A Game Theoretical Approach to Sharing Penalties and Rewards in Projects. Tilburg: University Center and Development of Econometric and Operations Research, the Netherlands.
ix. Fernandez, L. (2002). Trade's Dynamic Solutions to Transboundary Pollution. Journal of EnvironmentalEconomics and Management 43, 386-411.
x. Fudenberg, D., & Levine, D. K. (1988). Open-Loop and Closed-Loop Equilibria of Dynamic Games with Many Players. Journal of Economic Theory, 44, 1-18.
xi. Game Theory (2015). Dynamic Game. Retrieved from www.gametheory.net/dictionary/DynamicGame.html
xii. Game Theory (2015). Static Game. Retrieved from www.gametheory.net/dictionary/StaticGame.html
xiii. Gkonis, K. G. &Psaraftis, H. N. (2007). Investment Rules and Competition Patterns in LNG Shipping–A GameTheory Approach. National Technical University of Athens, Greece.
xiv. Global Technology Archive (2012). History of Global System for Mobile Communication in Nigeria(GSM). Retrieved from http://onlinenaijatech.blogspot.com.ng/2012/06/history-of-global-system-for-mobile.html
xv. Guldmann, J. M., &Kucukmehmetoglu, M. (2002). International Water Resources Allocation and Conflicts:The Case of the Euphrates and the Tigris. 42nd European Congress of the Regional Science Association,August 27-31, 2002, in Dortmund, Germany.
xvi. Hamers, H. J. M., Miquel, S., Norde, H.W., & van Velzen, S. (2003). Fixed Tree Game with Repeated Players. Tilburg University 2003-87.
xvii. Heaney, J., &Lippai, I. (2000). Efficient and Equitable Impact Fees for Urban Water Systems. Journal of WaterResources Management and Planning, March April 2000: 75-84.
xviii. Ijewere, A. A., &Gbandi, E. C. (2012). Telecommunications Reform in Nigeria: The Marketing Challenges. JORIND, 10(2), 193-198.
xix. Just, R., & Netanyahu, S. (2004). Implications of „Victim Pays" Infeasibilities for Interconnected Games with an
xx. Illustration for Aquifer Sharing under Unequal Access Costs. Water Resources Research, 40(5):W05S01.
xxi. Mattos, E., Vieira, M., Schmitz, E. A., &Alencar, A. J. (2014). Applying Game Theory to the Incremental Funding Method in Software Projects. Journal of Software, 9(6), 1435-1443.
xxii. Mediareach OMD Limited (2015). Media Facts. Lagos: Mediareach OMD.
xxiii. Montero, M. (2005). Altruism, Spite and Competition in Bargaining Games. School of Economics, University of Nottingham, United Kingdom.
xxiv. Morgenstern, O., & Neumann, J. V. (1953). Theory of Games and Economic Behaviour. Princeton University Press.
xxv. Ndukwe, E. (2005). Telecom Liberalization in Nigeria: Opening up the Market and Sector Reform paper presented at SATCOM.
xxvi. Nigerian Communications Commission (2016). Contribution of Telecoms Industry to GDP. Retrieved from http://www.ncc.gov.ng/stakeholder/statistics-reports/industry-overview#view-graphs-tables-7
xxvii. Nigerian Communications Commission (2016, November). Market Share by Operator (GSM) Report. Retrieved from http://www.ncc.gov.ng/stakeholder/statistics-reports/industry-overview#view-graphs-tables-2
xxviii. Nigerian Communications Commission (2016, November). Market Share by Technology Report. Retrieved from http://www.ncc.gov.ng/stakeholder/statistics-reports/industry-overview#view-graphs-tables-4

xxix. Oziegbe, A. (2011). Application of Game Theory to Business Strategy in Undeveloped Countries: A Case for Nigeria. Journal of Social Sciences, 27(1), 1-5.
xxx. Serghini, M. (2003). The Problem of Allocation of Costs of Mobilization of Water Resources.Men Women,32 (124), 20-24.
xxxi. Villiger, R. (2000). Game Theory and Traffic Control.Federal Institute of Technology, Lausanne, Switzerland.
xxxii. Wikipedia (2015). Game Theory. Retrieved from https://en.m.wikipedia.org/wiki/Game_theory
xxxiii. Wikipedia (2015). Linear Programming. Retrieved from https://en.wikipedia.org/wiki/Linear_programming
xxxiv. Wikipedia (2015). Nigerian Communications Commission. Retrieved from https://en.m.wikipedia.org/wiki/Nigerian_Communications_Commission
xxxv. Wikipedia (2015). Prisoner's Dilemma. Retrieved from https://en.wikipedia.org/wiki/Prisoner%27s_dilemma