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Research article

Competitive behaviour of major GSM firms' internet data pricing in Nigeria: A game theoretic model approach

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ABSTRACT

The study investigated the competitive behaviour of major GSM service providers' Internet data pricing in Nigeria. Two null hypotheses were tested: The major GSM service providers in Nigeria do not have a dominant pricing strategy; and there is no Nash Equilibrium for the pricing strategies of the major GSM service providers in Nigeria. The design was a longitudinal study of the active GSM subscribers and Internet data prices of major GSM service providers in Nigeria (MTN and the others). Two pricing strategies were employed, "charge N1000 per data plan" and "charge N1200 per data plan". A zero-sum payoff table was obtained from the data on GSM subscribers and Internet bundle prices in Nigeria. The payoff table was analysed using mixed strategy approach. The results revealed that each player has a dominant strategy. The game has a Pareto optimal Nash equilibrium with disparate dominant strategies for both players. The Nash equilibrium is that the other GSM firms charge N1000 per internet data plan while MTN charges N1200 per Internet data plan. At a price of N1000 and N1200 per Internet data plan, the earnings of the other GSM service providers and MTN are maximised respectively irrespective of what the other player does. The study concludes that major GSM firms can use game theory to model the pricing strategy of competitors and predict the behaviour of Internet data subscribers.

1. Introduction

Human systems are characterised by conflicts, competition, cooperation and interdependence. These peculiar situations permeate various systems such as firms' internal and external relations, markets, government and non-governmental organisations as well as political systems, among others. The competitive behaviours of these systems or subsystems, as the case may be, can be modelled using game theory. Specifically, game theory assists decision makers in predicting the outcomes of a group of interdependent and interacting firms where the action of one of the firms has significant influence on the payoff of the other participating players.

1.1. Global system of mobile telecommunication (GSM) in Nigeria

The inability of the Nigerian telecommunications limited (NITEL) to live up to expectation in the provision of telecommunication services made the advent of GSM a laudable idea in Nigeria. Unfortunately, from the onset, GSM services were very expensive and thus

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considered exploitative in Nigeria; especially when there were only two service providers (Econet and MTN). The euphoria of owning mobile phones coupled with inadequate legislative protection for consumers made the actors to treat consumers unfairly [26] . However, with the coming of the first National GSM service provider (Globacom) and the emergence of additional entrants into the industry, it became evident that it was no longer business as usual; Econet could not withstand the impending competition. It metamorphosed to Voodacom, later to Vmobile, then Zain and finally Airtel. The series of acquisition and de-acquisition in quick successions are indications of the intense rivalry that had characterized the GSM market in Nigeria.

When Airtel took over from Zain, it decided to change the pricing strategy of its acquiree so as to enhance competitiveness. Customers applauded the move and in no time, other GSM service providers followed suit in order not to be outperformed by Airtel's competitive pricing strategy. In terms of data plans, Airtel was also the first to adjust its prices for the 'cheap' Android market. However, poor network prevented them from reaping the intended benefits. Glo followed Airtels' initiative and later Etisalat, and lastly, MTN reluctantly followed.

Following the removal of price floors and customers' increasing awareness of the exploitative tendencies of the GSM firms, there appears to be no end to the price war that was triggered by the desire of the GSM service providers to outperform competitors. Each GSM operators appear to be on each other's throat developing and designing apparently new marketing strategies each day to win its competitors. To this end, this study models the competitive behaviour of GSM firms through their pricing strategies as a game and thus seeks to investigate how the pricing strategies of major GSM service providers in Nigeria are affected by the actions of competitors and how such strategies influence the pricing strategies of other competitors. The intensity of rivalry in the Nigerian GSM market has forced most marginal firms to retract, thus leaving the market with four major actors (Globacom, Mtn, Airtel and 9mobile).

The aim of this study was to employ game theory to model the competitive behaviour of the major GSM companies in Nigeria with specific focus on their pricing strategies of Internet data bundles. The specific objective were to find out whether there was a dominant strategy and whether there was a Nash equilibrium with respect to the pricing strategies of the GSM service providers in Nigeria. In view of the foregoing, the following null hypotheses were tested:

H_0 1: The major GSM service providers in Nigeria (MTN and the others) do not have a dominant pricing strategy

H_0 2: There is no Nash Equilibrium for the pricing strategies of the major GSM service providers in Nigeria (MTN and the others).

2. Literature review

2.1. Introduction

A key feature of business strategy is competitor analysis because of the desire to gain competitive advantage over competitors. A quantitative technique employed in analysing the strategies for tackling competitive situations where the outcome of each participant's choice of action is a function of what the other participants do is known as game theory ([4, [9]_ and [3]. Game theory is the competitive interplay among players. It involves, mainly, decision making under conditions of conflict, competition and cooperation. Therefore, it focuses on the strategies employed by decision makers under conditions of conflict, competition and cooperation and how such strategies are can help to maximise the benefits of the players. To this end, there are cooperative and non-cooperative games depending on whether the game was necessitated by cooperation, competition or conflict.

2.1.1. Cooperative games

A cooperative game is one that involves the collaboration of players to pursue a common interest. Here, each player understands the move of his opponents and there is a desire to maximise the interest of the players through cooperation. The outcome of the game will be equally beneficial to all players provided there is no betrayal by any of them.

2.1.2. Non-cooperative game

Unlike the cooperative game each player pursues its own interest and adopts the strategy that will enable it to outperform its opponents. Consequently, players are usually not aware of the strategies of opponents until such strategies are deployed. At best, what each player does is to guess the moves of its opponents. This is the case in business competition, especially in the case of oligopolistic firms that use price wars to compete for customers' patronage and hence market shares.

2.2. Competitive behaviour

Most industries in industrially advanced and less developed countries are characterised by competitive behaviours in varying degrees. The same argument is applicable to Nigeria which has the largest market in Africa. Striving to do one's best, having a sense of rivalry, striving to outdo others, among others, all describe competition and competitiveness. To this end, competitive behaviour includes every actions and steps taken by a firm to increase its relevance while diminishing the competition. In this regard, competitive behaviour primarily aims at gaining competitive advantage over competitors. Competitive behaviour concerns the extent to which individual firms compete against each other through pricing promotion and other strategies aimed at gaining higher market shares, earning higher profits or any other advantage that may enhance their position in the market place.

In many markets, apart from monopolies, competition is the major driving force of change. As companies strive to outdo competitors, they innovate, enhance the quality of their products, provide better services, deliver faster and employ other strategies that will make their products better than those of competitors in the eyes of the consumers. Competition enhances the degree to which firms' outputs are consistent with customer specifications. Without competition, companies satisfice. They provide satisfactory levels of service but fail to excel [16].

2.3. Empirical review

Shobande and Akinbomi [23] studied "competition dynamics in Nigerian aviation industry using game theoretic approach." The model analysed the dynamics of competition among firms in the Nigerian aviation industry. They employed the prisoner's dilemma to provide optimal strategy and concluded that using the strategy will enable the players to share the market profitably [19] applied game theory to the coordination of pricing, advertising, and inventory decisions in a competitive supply chain for both the manufacturer and the retailers who are able to determine the number of orders for each product and have the capacity to make their decisions simultaneously. The proposed model is based on a non-cooperative Nash game with pricing and inventory decisions using an iterative solution algorithm to find Nash equilibrium point of the game. Based on numerical examples and comprehensive sensitivity analysis the optimal decision is confirmed.

Khosroshahi et al [15] employed game theory to "pricing decisions considering CSR and a new consumer satisfaction index using transparency-dependent demand in sustainable supply chains" to ascertain a manufacturer's transparency on the profits of the supply chain members and customer satisfaction. The results show that using the equilibrium solution the manufacturer fares better if he uses CSR and that a higher level of transparency of the manufacturer will elicit higher demand and supply chain profit and a higher level of greening also elicits more demand and supply chain profit.

Selim [22] employed game theory to examine strategic pricing during price wars in a market scenario towards a converging solution of Nash equilibrium using Bertrand Game beginning with a simple version of a game involving two players with undifferentiated products who move simultaneously by merely choosing their prices. Subsequently, they extend the market scenario to a differentiated Bertrand Game for a market scenario based two players. The results suggest that the incumbent must maintain his price, even if faced by a lower priced competitor. A unique Nash equilibrium arises when one player differentiates his products and charges higher prices compared to the other player. Thus, when product differentiation is used to augment price competition, price wars and product quality, it does not lead to price convergence, neither does it necessarily lead to price reductions over time.

Anwar et al [4] applied game theory to resource allocation in heterogeneous wireless networks. They evaluated the techniques as well as the advantages and constraints associated with game-theory modelling of resource allocation in wireless networks. They concluded that the Sharpe value method is applicable in future research [7]. investigated "modelling pricing strategies using game theory and support vector machines." They presented a model of price competition in the credit industry using game theory. They employed a model consisting of a market level game that determines the marginal cost, demand, and efficiency of the competitors. They estimated demand using support vector machines.

Srinivasan et al [24] employed game-theory based dynamic pricing strategies for demand side management in smart grids to encourage consumers' participation in peak load reduction so that they can obtain incentives in return. They evaluated a game theory based dynamic pricing strategy for Singapore electricity market using the residential and commercial sector. Subsequently, they tested the proposed pricing model with five load and price datasets using weekdays, weekends, public holidays and the highest/lowest demand in the year. Three pricing strategies are evaluated and compared. The results indicated that RTP maximises peak load reduction for the residential sector and commercial sector significantly [25]. used game-theory to model port competition for intermodal network and pricing strategy to maximizing profit considering the shipper's route choice behaviour. In line with the characteristics of the Nash equilibrium solution for reduced strategy sets, they adapted a Nash equilibrium solution. They applied the model to a case involving the competition between two ports (Dalian & Yingkou) in China. An obvious link between dry port location and geography was found.

Dong and Zhong [10] investigated tacit collusion of pricing strategic game between regional ports in Yangtze River economic belt under three scenarios. They found simultaneous pricing game between regional ports, which reflected the pricing strategy independently adopted; considered two competing ports that make sequential pricing decisions; and employed an infinitely repeated game model for regional ports to test the stability of Nash equilibrium under the first, second and third scenarios respectively. Results showed that there is a certain degree of tacit collusion of pricing strategy between regional ports under competition. Specifically, the observed tacit collusion of pricing strategy stabilizes as the number of regional ports games increases.

Aguiar et al. [2] examined cooperative games using Excel. They discussed Nash equilibrium in pure and mixed strategies through the provision of solutions using mini-max criterion, John Von Neumann theorem as well as through the illustration of mathematical modelling of a hypothetical game theory problem. They further proposed a solution of linear programming using Microsoft Excel [3]. investigated game theory and its application to business strategy in undeveloped countries using Nigeria as a reference case. Results of the investigation suggest that the game theory model is desirable in business strategy and has the ability to enhance business decision in the less developed countries of the world [12]. applied game theory to supermarket pricing for everyday low pricing (EDLP) firms and High Low pricing (HLP) firms. He employed intuition and deductive logic to show supermarket chains reaching equilibrium that maximises profits for none of the chains. The lower profits associated with this equilibrium was attributed to higher inventory and promotion costs. He considered HLP strategies to be imperative because once a competitor engages in promotion it is likely to increase its profit at the expense of the other chains. This prompts all chains to simultaneously engage in promotional activities in order to guard against lost sales and profits to the offensive competitor.

Schuur et al. [21] used a non-cooperative market with many replacement items and a sizeable overall market that is fairly price-sensitive. They assumed a market share attraction model, in which the allure of any product is a linear function of its price, which determines the price-demand relations. The parameters of the linear function represent the brand image of the product. And the authors further developed explicit formulations for the best-response tasks for the general situation of numerous replacement products. They obtained closed-form formulas for the pricing at Nash equilibrium for the specific scenario of two replacement items. According to the authors, these phrases assist managers in altering their marketing strategies outside of pricing to generate substantial individual gains. They demonstrated how the analysis of the profit loss resulting from competition is made possible by closed-form Nash equilibrium.

Keehan et al. [14] investigate a spatial firm rivalry frequently examined in linear marketplaces where consumers always patronise the closest retailer. The authors developed a probability vector used in this instance to predict client behaviour. They show that for convex probability vectors and probability vectors displaying a certain symmetry non-convergent Nash equilibria where businesses cluster at various places in the market always occur but non-convergent Nash equilibria are unlikely to arise for concave probability vectors.

Boz and Koç [8] examine the existing GSM consumers' emotional reactions to their GSM operators after being exposed to sales promotion efforts by competing GSM providers to attract new customers. Additionally, the authors compare consumers' brand loyalty to their GSM service providers before and after these marketing activities. They used questionnaires, an eye tracker, and facial recognition software to gauge how customers felt about GSM providers' incentives. They found that even satisfied consumers may migrate to another service provider if a more appealing offer is made. Consequently, they recommended that practitioners prioritise customer retention instead of focusing primarily on obtaining new clients. They also stressed the need for GSM providers to beware of the long-term harm targeted marketing can cause its consumers.

Ayaga and Nnabuko [5] investigate how competing strategies affected consumer satisfaction in Nigeria's mobile phone market. They used a sample size of 400 GSM users based on Taro Yamani formula. The authors documented that competitive strategies are beneficial to customer satisfaction.

2.4. Gap in literature

Game theory is not deficient in literature. The empirical review shows that Anwar et al. [4] applied game theory to resource allocation in heterogeneous wireless networks. Debnat et al. [9] applied game theory to project management in Czech Republic, Aguiar et al. [2] examined cooperative games using Nash equilibrium in pure and mixed strategies [3], investigated application of game theory to business strategy in undeveloped countries using Nigeria as a reference case, while [12] applied game theory to supermarket pricing for everyday low pricing (EDLP) firms and High Low pricing (HLP) firms. [_inegbedion_and_obadiaru_2018] examined brand loyalty in the Nigerian Telecommunication sector using Markov chain analysis. Adeoye et al. [1] applied game theory to horticultural crops in South Africa, Bockova et al. [6] applied game theory to project management, Samuelson [20] applied game theory in economics, Lemaire [17] applied game theory to cost allocation and Oluyole et al. [18] applied game theory to Cocoa production management. Among these studies, only [3,12] studied application of game theory to business strategy with only [12] specifically focusing on pricing strategy. Besides, none of the studies appears to have employed actual data of firms in Nigeria but hypothetical data. This study sought to fill these gaps.

2.5. Theoretical framework

This study employs the Nash Theorem as its framework. Nash theorem states that every n-player game with a finite number of players and action profiles has one or more Nash equilibrium [11,13]. Although not every game has Nash equilibrium, it is categorically stated in Nash's theorem that all n-player games with finite number of pure strategies have Nash equilibrium. Nash equilibrium applies to uncooperative games.

2.5.1. Nash Equilibrium

Payers in a game seek to maximise their payoffs by taking appropriate strategic actions at their disposal at any given point in time. The combination of the best-chosen strategy for every player is called equilibrium. If a player is not able to gain by adjusting his strategic actions while keeping the strategies of other players unchanged, then the value that cannot be improved upon is a Nash Equilibrium. Once it is certain that the payoffs in a game may not be influenced using any further combination of strategies by one player when other players' strategies are unchanged, "it can be said that the game has attained a Pareto Optimal Nash Equilibrium" (Anwar Anwaret al. 2018).

$$\text{Given that } \mathrm{w} \in \mathrm{W}, \text{for all } \mathrm{i} \in \mathrm{N}, \text{a strategy profile and } \lambda \mathrm{i} \in \mathrm{Ai} \tag{1}$$

Furthermore, let $\phi\mathrm{i}, \lambda\mathrm{i}\ (\mathrm{w}) = \max\{0, \mathrm{ui}(\lambda\mathrm{i}, w - i) - \mathrm{ui}(\mathrm{w})\}$.
And let f: $\mathrm{W} \rightarrow \mathrm{w}$ be defined by $\mathrm{f(w)} = \mathrm{w}'$, where

$$W_i^{'}\ (\lambda \mathrm{i}) = \frac{w_i(\lambda \mathrm{i}) + \phi i, \lambda \mathrm{i}\ (\mathrm{w})}{\sum\limits_{b_{i\in A_i}} w_{i(b_i)+\varphi_i(W)}} = \frac{W_i(\lambda \mathrm{i}) + \phi i, \lambda \mathrm{i}\ (\mathrm{W})}{1 + \sum\limits_{b_{i\in A_i}} \varphi_{i,b_i(W)}} \tag{2}$$

The function that maps w to $w^{'}$ denoted by equation (2) is a strategy profile that shows each agents actions as better responses to w received increased probability mass. Since $\phi_i(\lambda \mathrm{i})$ is continuous, the function "f is continuous and W is convex and compact and, f: W → w" [11]. Consequently, f has at least one fixed point and the fixed point of the function f is the Nash equilibrium.

The basic idea behind the Nash equilibrium in a multi-player game is that each player (P_i) will be indifferent to the actions chosen by the other n-1 players at the Nash Equilibrium. In other words, each player will not regret his action owing to the actions of other players. Formally, a set {u^{1*}, u^{2*},… u^{n*}} of actions is said to be a deterministic *Nash equilibrium* if:

$$L_i\left(u^{1*}, u^{2*}, u^{3*}, .. u^{i*}, .., u^{n*}\right) = \underset{u^i \in U^i}{min} \left\{L_i\left(u^{1*}, u^{2*}, u^{3*}, u^{(i-1)*}, u^{i*}, u^{n*}, u^{(i+1)*}, u^{3*}\right\}\right. \tag{3}$$

3. Methodology

The ideas of a two-person game can be easily applied to more than two players. The major difference is the use of complicated notation, which then makes the concepts in more than two players to appear more difficult. But there are basically no fundamental differences.

3.1. Research design

The study employed secondary data obtained mainly from company records and subscribers' data obtained from the Nigerian Communications Commission (NCC) bulletins as well as other statistical bulletins. The research design is a longitudinal study of customer subscription and pricing strategies of the three major GSM companies under investigation from the period 2016–2021. The population of the study consists of the major global system of telecommunication companies (GSM) in Nigeria. Since there are four major GSM service providers in Nigeria, all the global system of telecommunication companies (MTN, Airtel, Globacom and 9mobile) were investigated. These company records as well as the subscribers' data from the NCC used were sourced from Internet websites. Research data were analysed using mixed strategy Nash Equilibrium.

3.2. Model specification

The payoff table of the leading GSM service provider (MTN) in the Nigerian telecommunication industry and the other three major service providers (Airtel, Globacom and 9mobile) was constructed from available data on Internet subscribers in Nigeria. Since, the leading service provider's gains is the loss of the other service providers and vice versa, the payoff table was designed consistent with a zero-sum game.

3.2.1. Mixed strategy Nash equilibrium model of a zero-sum game

Given a payoff table for two players.

Player one (A)	Player two (B)	
	m	n
	a.	b

If player one plays row one with probability p and row 2 with probability 1 – p while player two plays column one with probability q and column two with probability 1 – q, then A's action will depend on B's action and vice versa. The degree of dependence of A's action on B's action and that of B on A is illustrated as follows:

If B plays column one, then A's payoff will be: mp + a (1 – p)

$$\text{i.e. } mp + a - ap = a + p\,(m - a) \tag{4}$$

If B plays column 2, then A's payoff will be: n p + b (1 – p) = np + b – bp

$$\text{i.e. } b + p\,(n - b) \tag{5}$$

Equations (i) and (ii) → a + p (m – a) = b + p (n – b)
i.e. a – b = pn – pb – pm + pa
a – b = pn + pa – pb – pm
a – b = p (n + a – b – m)

$$p = \frac{a - b}{a + n - b - m} \tag{6}$$

B's payoff
Player B's payoff will depend on A's strategy.
If A plays row 1, B's payoff will be: mq + n (1 – q) = mq + n - nq

$$= n + mq - nq \tag{7}$$

If A plays row 2, B's payoff will be: aq + b (1 – q) = aq + b – bq

$$= aq - bq + b \tag{8}$$

Equations (iii) and (iv) → m + mq – nq = b + aq – bq
m – b = aq – bq + nq – mq
m – b = q (a + n – b – m)

$$q = \frac{m - b}{a + n - b - m} \tag{9}$$

The implication is that player A can hold its losses to zero (0) by adopting a mixed Nash equilibrium strategy of:

$$p = \frac{a - b}{a + n - b - m} \text{ and } 1 - P = \frac{n - m}{a + n - b - m}$$

Also, B will hold its losses to zero (0) by adopting a mixed Nash equilibrium strategy of:
$q = \frac{m-b}{a+n-b-m}$ and 1-q $= \frac{a+n-2m}{a+n-b-m}$

$$\text{The value of the game is } \frac{a_{11}a_{22} - a_{12}a_{21}}{a_{11} + a_{22} - a_{12} - a_{21}} = \frac{bm - an}{m + n - a - n} \tag{10}$$

Note: In the event of a payoff of higher dimension than 2 × 2, we use strategic dominance rule to reduce it to 2 × 2 and apply the Nash equilibrium mixed strategy.

This study considers the four major GSM companies in Nigeria (Mtn, Globacom, Airtel and 9Mobile). As consistent with oligopolistic firms, the major instrument of competitiveness is pricing. Therefore, we consider pricing of Internet data bundles for the four firms. Specifically, we examine the pricing strategy of MTN vis-à-vis the pricing strategy of the three other major GSM service providers in Nigeria in order to examine subscribers' reaction to the pricing strategies. MTN has majority of the Internet subscribers in Nigeria [_ncc_2019]. Giving that MTN's losses are the gains of other GSM service providers (others) and the losses of other GSM service providers are the gains of MTN, we model the competitive behaviour as a zero-sum game.

4. Results

Table 1 presents the internet subscribers in Nigeria by major GSM networks for the period 2012–2016. The results show that the other networks had the highest number of subscribers within the period and their subscribers kept increasing marginally overtime. Table 2 presents the Internet subscribers of the major GSM service providers five months after the removal of data price floors. The results show that the removal of data floors caused Globacom to gain 1,700,000 and 7,000,000 subscribers from Airtel and MTN in quick succession. Table 3 presents the market shares of major GSM service providers in the Nigerian telecommunication industry for the period 2018–2021. The results show that other networks had the highest number of subscribers within the period, the active number of subscribers kept increasing from 2018 to 2020 but there was a decrease in 2021. This decrease may not be unconnected by the disruptions caused by COVID-19 pandemic in 2020. The same trend applied to MTN whose active number of subscribers were relatively lower than those of other networks. Table 4 presents the market shares of GSM subscribers for the period 2018–2021. The results show that MTN had a positive change in market shares within the period 2018–2019 and negative changes for the periods 2019–2020 and 2020–2021, thus indicating that their proportion of subscribers was consistently on the decline after the period 2019. Unlike MTN, the other networks had a negative change in the period 2018–2019, but had positive changes in 2019–2020 as well as 2020–2021, thus indicating that the proportion of the subscribers was continuously on the increase after 2019.

Table 5 presents the prices of internet data per gigabyte for each of the GSM service providers. The results indicate that MTN and Airtel charge N667 per gigabyte while Glo charges N385, which is relatively lower. The implication is that the price charged per gigabyte by the other networks is relatively lower than what MTN charges. Table 6 shows the payoff (in N Billions) for MTN and other networks. Table 7 presents the zero-sum equivalent of Table 6.

From the zero-sum payoff table of MTN and the other major GSM service providers in Nigeria (see Table 7), there was no saddle point since N6, 950,000,000 ≠ N8, 000,000,000. Consequently, the Nash equilibrium of the game was determined using mixed strategy.

4.1. *Application of the mixed strategy Nash Equilibrium to the data*

From Table 7, if other GSM service providers charge N1000 (row 1) with probability p and N1200 (row two) with probability 1 – p. Then, if MTN charges N1000 (column one), other GSM service providers' payoff will be:

$$8p + 4.7\ (1 - p), \text{i.e. } 8p - 4.7p + 4.7 \tag{11}$$

Table 1
Internet subscribers data.

	2016	2017	2018	2019
MTN	31,753,369	36,069,597	43,899,957	54,113,148
Other Network	60,126,663	62,617,751	68,155,915	71,615,180

Source: NCC Data report (2019).

Table 2
Internet Subscribers five months after the removal of Data floor prices.

	Airtel	Glo	MTN	Losses	New Shares
Airtel	15,300,000	1,700,000	0	2,400,000	15300000
Glo	0	26,300,000	0		31300000
MTN	0	7,000,000	32,400,000	10,000,000	32400000
Gains		5,000,000			

Source: Author's computation 2022.

Table 3
Active GSM subscribers (2018–2021).

	MTN	Others	Total
2018	43,899,957	57812739	101,712,696
2019	54,113,149	63456831	117,569,980
2020	65,359,306	81394392	146,753,698
2021	58,812,428	77,051,893	135864321

Source: Nigeria communications commission (2021). Subscriber/network data Annual Report. Policy competition and economic analysis department.
file:///C:/Users/User/Downloads/Year-end%20Performance%20Report%202021.pdf.

Table 4
Market share of Active GSM lines.

	2018	2019	2020	2021
MTN	0.4316	0.46	0.4454	0.4329
Others	0.5684	0.54	0.5546	0.5671

Source: Author's computation from Table 1 (2022).

Table 5
Internet Data Prices of Major Service providers.

	Price per Megabyte (2016)	Price per Gig (2016)	Price per Data Plan of 1.5 [_gig_2022]	Price per Gig (2022)	Price per Megabyte (2022)
Airtel	0.52K/MB	N520	N1000	N667	67K
Glo	0.21K/MB	N210	N1500	N385	39K
MTN	0.45K/MB	N450	N1000	N667	67K

Table 6
Payoff table of returns (N Billion) due to pricing by MTN and other Networks.

	MTN			
Other Networks		1000	1200	42,540,000
	1000	81.4, 65.4	57.8, 43.9	
	1200	63.5, 54.1	77.1.58.8	

Source: Authors' computations from Tables 1 and 2 (2022).

Table 7
Zero-Sum format of Table 5.

	MTN Subscribers (Millions)			Min	Max
Other Network Subscribers (Millions)	Price	1000	1200		6.95
	1000	8	6.95	6.95	
	1200	4.7	9.15	4.7	
		8	9.15		
	8				

Source: Authors' computations from Table 4 (2022).

Then, if MTN charges N2000 (column two), other GSM service providers' payoff will be:

$$6.95\text{p} - 6.95\text{p} + 6.95 \text{ i.e. } 6.95\text{p} + 6.95(1 - \text{p}) \tag{12}$$

Equations (11) and (12) imply that 6.95p − 6.95p + 6.95 = 6.95p + 6.95(1 – p)

Therefore 5.5 p = 4.45 and p = $\frac{4.45}{5.5}$ = 0.81. Consequently, 1 – p = 0.19.

Thus, other major GSM service providers can hold their losses to zero (0) by adopting a mixed strategy of P = 0.81, i.e. charge a price of N1000 with probability 0.81 or charge a price of N 1200 with probability 0.19. The implication is that the other GSM companies' dominant strategy is to charge N1000 (row I). This is their optimum strategy under the Nash equilibrium.

In the same vein, we can determine the optimum strategy of MTN as follows: let MTN charge N1000 (column 1) with probability q and N1200 (column 2) with probability 1-q. Then, if other major GSM service providers charge N1000 (row one), the payoff to MTN will be:

$$8\text{q} + 6.95\ (1 - \text{q}). \text{ I.e. } 8\text{q} - 6.95\text{q} + 6.95 = 1.05\text{q} + 6.95 \tag{13}$$

If other GSM service providers decide to charge N1200 (row 2), then, MTN's expected payoff will be:

4.7q + 9.15 (1 –q), that is, 4.7q + 9.15–9.15 q

$$= -4.45\ \text{q} + 9.15 \tag{14}$$

(iii) And (iv) imply that 1.05 q + 6.95 = − 4.45 q + 9.15.

i.e. 5.5 q = 2.2

Thus, q = 0.4 and 1 – q = 0.6

The implication is that MTN can hold its losses to zero (0) by adopting a mixed strategy of q = 0.4; i.e. charge N1000 with probability 0.4 or charge N1200 with probability 0.6. Thus, MTN has a dominant strategy, which is to charge N1200 (column II). This is their optimum strategy under the Nash equilibrium.

Value of the Game (V)

$V = \frac{a_{11}a_{22} - a_{12}a_{21}}{a_{11} + a_{22} - a_{12} - a_{21}}$

i.e. $V = \frac{23.13x\ (18.81) - (10.82)x(9.05)}{23.13 + 18.81 - 10.82 - 9.05}$

$V = \frac{435.08 - 97.921}{41.94 - 19.87} = \frac{337.159}{22.07} =$ N15.28Billion

Thus the game is not fair. It is in favour of the other GSM service providers. Although both players (other major GSM service providers and MTN) have a Nash equilibrium the game is favourable to the other three major giants (Airtel, Glo and 9mobile). The results are consistent with theory as MTN currently controls 43.29% of the shares in the Nigerian Internet data market while the other firms (Airtel, Glo and 9mobile) control 56.71%.

4.2. Discussion of findings

The first hypothesis was: The major GSM service providers in Nigeria do not have a dominant pricing strategy and second hypothesis is: There is no Nash Equilibrium for the pricing strategies of the major GSM service providers in Nigeria. The results of the study indicate that the other three major GSM companies (players) have a dominant strategy of charging N1000 per data plan as the probability of charging N1000 per 1 per data plan is 0.81 while the probability of charging N1200 is 0.19. On the other hand MTN has a dominant strategy of charging N1200 per data plan as the probability of charging N1200 per data plan is 0.6 while the probability of charging N1000 is 0.40. Thus, the first null hypothesis is rejected. It is pertinent to note that the dominant strategy of other GSM service providers (N1000 per data plan) is not consistent with that of MTN (N1200 per data plan). The dominant strategy of N1000 for other GSM service providers as against N1200 for MTN indicates that a percentage change in the price of MTN data plan yields less than proportionate change in the demand for Internet services. Thus, the demand for Internet services by MTN internet customers in Nigeria is inelastic at this point. Consequently, MTN can enhance its revenues through marginal increases in their charges for Internet data plans without significant repercussions, owing to the relative inelastic demand for its Internet services. To this end, an increase in the price of Internet data plans above N1000 will guarantee MTN adequate rewards, irrespective of what the other players decide to do provided the increase does not exceed N1200. This is the Pareto optimal Nash equilibrium and it is consistent with logic of the prisoner's dilemma. Thus, the second null hypothesis is rejected.

The results are consistent with [7] who presented a model of price competition which stipulates the prices at which competitors will be at equilibrium under prevailing circumstances. The results are further consistent with [25] port competition for intermodal network and pricing strategy that employed Nash equilibrium solution for reduced strategy sets and profit optimisation. As well as Keehan et al.' (2022) non-convergent Nash equilibria for convex probability vectors. The results also support [10] tacit collision of pricing strategy game between regional ports in Yangtze where tacit collusion of pricing strategy was found to stabilize as the number of regional ports games increases. The results are also consistent with [12] application of game theory to supermarket pricing for Everyday low pricing (EDLP) firms and High Low pricing (HLP) firms where the supermarket chains reach equilibrium that maximises profits for none of the chains. Nonetheless, the results are inconsistent with [2] cooperative games solution to firm pricing as against competitive strategy of this article.

The results also support [23] findings on competition dynamics in Nigerian aviation industry in which the prisoner's dilemma was used to provide optimal strategy that enables the players to share the market profitably [19], game theoretic approach to coordination of pricing, advertising, and inventory decisions in a competitive supply chain where Nash equilibrium was used to provide optimal decision for competing firms, as well as [22] game theoretic solution to strategic pricing in a case of price wars in a market scenario towards a converging solution of Nash equilibrium where the incumbent was advised to maintain his price, even if faced by a lower priced competitor. A unique Nash equilibrium arises when one player differentiates his products and charges higher prices compared to the other player. The importance of Selim; s finding is that at the Nash equilibrium, the firms fortunes are not affected by the actions of competitors whether they increase or decrease their prices.

For the other GSM service providers, the dominant strategy of N1000 per data plan may not be unconnected with the relatively lower price per gigabyte bundle currently charged by Globacom (N385 per gigabyte, which makes it difficult for MTN to compete with the other GSM service providers on the N1000 data plan since the other GSM service providers have a relative advantage in terms of cost owing to Globacoms' perceived cost advantage. The low probability of charging N1200 per data plan of 0.19 may also be suggestive of a highly elastic demand for the data plans of the other GSM service providers.

4.3. Policy implications

Decision making under conditions of competition can prove difficult at times because of the players' inability to know the actions and/or strategies of opponents. But the players want to get the best results possible. The telecommunication industry in Nigeria is a very competitive industry with intense rivalry among key players. It is this intense rivalry that culminated in the retraction of marginal firms, thus leaving four major four major actors (Globacom, Mtn, Airtel and 9mobile). The results of this study imply that through the application of game theory, using relevant data, it is possible for each GSM service provider to be at equilibrium and thus maximise their profits. Specifically game theory can be used by key players in the Nigerian GSM market to study the pricing strategy of competitors as well as the behaviour of the Internet subscribers given the pricing strategies of the GSM service providers. The use of game theory can assist key players to be equipped with information for strategic decisions. At equilibrium the actions and/or inactions of competitors will not affect the fortunes of a particular firm. Therefore, all that is required is for strategic managers and key stakeholders to determine this equilibrium through adequate game theoretic modelling. Thus, game theory will enhance a firm's capacity to make optimum decision in the midst of competitors.

By applying game theory, especially the Nash equilibrium which presents the best price and thus places each firm in a position where it cannot improve its lot and where the activities of competitors cannot undermine its fortunes, game theory helps participants to avoid the dire consequences of price wars characteristic of the oligopolistic theory of the firm. Thus, rather than reducing prices indiscriminately in reaction to competitors' price cuts, a firm can determine the Nash equilibrium and stick to the attendant price and thus hold their losses to zero. This becomes even interesting when the firm has a dominant strategy. The implication for data pricing is that data pricing will not be arbitrary. Modelling of competitive behaviour will help to ensure that there is a level of stability in pricing as the Nash equilibrium price will be associated with some measure of stability. To this end strategic managers of the other GSM companies should embrace the mixed strategy Nash equilibrium of N1000 per Internet data plan while the strategic managers of the MTN should embrace the mixed strategy Nash equilibrium of N1200 per Internet data plan to ensure that they moderate their approach to pricing and ensure that they fulfil their objective of efficient service delivery with some degree of flexibility to ensure the going concern of their firms. Since pricing strategy involves price increases, strategic managers should endeavour to match every price increase with additional value so as to provide a justification for their pricing strategy rather than allowing indiscriminate price cuts or hikes. Consequently, they should strive to continuously improve the quality of services offered. Such improvement in product quality will serve to justify price increases when necessary.

5. Conclusions

The research conclusions are that: key players in the GSM market can sustain the going concern of their firms by pricing their services in a manner that will enhance their turnover without necessarily overstretching the consumers. Specifically, the optimum pricing strategy is that other GSM companies should charge N1000 per Internet data plan and MTN should charge N1200 per Internet data plan to ensure that they maximise their earnings and thus sustain the going concern of their firms. Using this strategy, irrespective of what the opponents do, a firm is assured of its optimum returns.

This study has made significant contribution to knowledge in management sciences and operations research, being about the very first or among the very few to have employed game theory to model competitive behaviour in the Nigerian telecommunication industry. First the study has updated the studies on game theory in Nigeria. Furthermore, the study is about the only one till date to employ actual data of firms' prices and customers' data subscription in the telecommunication industry to model competitive behaviour of GSM service providers in Nigeria using the pricing strategy of GSM firms rather than hypothetical or simulated data. The study has thus, validated the usability and suitability of game theory to the modelling of consumer behaviour in the face of competition. This study has thus bridged the gap in knowledge regarding the modelling of competitive behaviour of firms by employing the subscriber base of major GSM service providers in Nigeria vis-à-vis the prices of Internet data bundles. This is a point of departure from most previous studies on game theory in Nigeria. The study has further reinforced [22] assertion that price decreases by competitors must not always be tackled through retaliations to stimulate price wars but that a firm can determine its Nash equilibrium vis-à-vis its competitors and stick with that equilibrium irrespective of what its competitors do.

The study has some limitations which have significant implications for the generalizability of the results. First, the data employed were obtained from secondary sources; the authenticity of the data has implications on the findings of this study. However, since the Nigerian Communications Commission (NCC) is statutorily empowered to regulate the telecommunication sector, its records are deemed to be reliable.

Secondly, the study assumes that pricing strategies of the GSM service providers is solely sufficient to significantly influence the behaviour of Internet subscribers. The study does not factor in the influence of brand loyalty on customers' subscription behaviour, neither did it reckon with service providers' goodwill as a result of excellent call services and customer relationship management, nor did it reckon with the network connectivity of the GSM service providers. Besides, if both players reduce prices simultaneously, does it amount to the same effect? To what extent can a player reduce its price without eroding its profit margin completely? In the same vein the degree of price increase that will deter customers from continuous patronage is not indicated. These could have implications on the results of this study. Future studies should endeavour to examine the percentage increases in prices to make way for objective comparison of subscribers' actual switching behaviour.

A third limitation is that the study did not exhaust all the factors that influence the subscribers' subscription to Internet data bundles. Not all subscribers' subscription to Internet data bundles is attributable to the pricing strategies of the service providers. Some of the subscribers' subscription behaviour is informed by constraints, especially none availability of alternatives owing to the absence of competitors in their vicinity.

Lastly, the study assumes that every other thing will be held constant, thus making the consumption of telecommunication services the main concern of the customers. In practice, some of the other products and/or services consumed by the consumers may give some source of concern to consumers. Issues like changes in income, prices of other commodities, especially essential ones, recession and macroeconomic policies may alter consumers' patronage and thus constitute constraints to the results of this study.

Ethical approval

This article does not contain any interaction with human participants; thus, none of the authors had any interaction with human participants for the purpose of eliciting data neither does it contain any experimentation with animals.

Conflict of interest

I declare that the authors have no conflict of interest and the authors did not receive any grant for the study.

Implementation cost of replicating the study

As a study that relies on secondary data which are publicly available, the cost of data collection is within the confines of the cost required to access the National Bureau of statistics website and other internet sources. In a nutshell, the cost of replicating the study is similar to that required for any other standard article. There may be little variations imposed by locations. The Article Processing Charge (APC) will depend on the Journal of interest as well as on the chosen option (Green or Golden pen). Nevertheless, a maximum of N200, 000 ($330), excluding APC is adequate to replicate this study.

Author contribution statement

Henry Egbezien Inegbedion: Conceived and designed the analysis; Analyzed and interpreted the data; Wrote the paper.
Abiola John Asaleye: Analyzed the data.
Eseosa David Obadiaru: Contributed data.

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Data availability statement

The data on the prices of GSM service providers in Nigeria are publicly available on Google.

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