GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

THE INDUSTRY OF MOBILE PHONE DEVICES IN THE 2000s: ANALYSIS OF APPLE, NOKIA AND SAMSUNG INNOVATIVE PERFORMANCE BASED ON THE GAME THEORY

A INDÚSTRIA DE TELEFONIA MÓVEL NA DÉCADA DE 2000: ANÁLISE do DESEMPENHO INOVATIVO DA APPLE, NOKIA E SAMSUNG COM BASE NA TEORIA DE JOGOS

Angelo Rondina Neto[1]
Mateus Boldrine Abrita[2]
José Luiz Parré[3]

Abstract: The mobile phone devices industry, whose structure is an oligopolistic technological frontier, suffered a structural change in the 2000s, with firms once leaders giving way to emerging ones. This study's hypothesis is that this chance happened due to different innovation strategies adopted by the firms. The objective is to analyze innovation strategies' influence on business performance of the industry's firms in general, with Apple, Nokia and Samsung cases in particular – considered representative firms of the industry for the period. The methodology used was the game theory, comparatively analyzing two games with Nash-Bayesian equilibrium. The results show that, in the face of an aggressive strategy of innovation by products of the first firm (Apple), there is a worse outcome for the company that competes by innovations by product (Nokia) than by markets (Samsung). It is concluded that companies should pay attention to their innovative strategies to remain operative in dynamic markets.

Key words: Mobile phone devices industry; Nash-Bayesian game; Economy of Innovation.

Resumo: A indústria de dispositivos de telefonia móvel, cuja estrutura é de fronteira tecnológica oligopolista, sofreu uma mudança estrutural na década de 2000, com firmas antes líderes perdendo espaço para firmas emergentes. A hipótese do trabalho é que as diferentes estratégias de inovação adotadas pelas firmas foram responsáveis por essa mudança estrutural. O objetivo do trabalho é analisar a influência dos tipos de inovação no desempenho das empresas da indústria em geral, e da Apple, Nokia e Samsung em particular, firmas tidas como representativas. Para tanto, utiliza-se como metodologia um modelo com base na teoria de jogos, analisando dois casos. Os resultados, sob equilíbrio Nash-Bayesiano, evidenciam que, em face a uma estratégia agressiva em inovações via produtos por parte da Apple, há um pior resultado para a empresa competidora que decide competir com inovações via produtos (caso da Nokia) do que a que compete em inovações via mercados (caso da Samsung).
Palavras-chave: Indústria de dispositivos de telefonia móvel; Jogo Não Cooperativos Nash-Bayesiano; Economia da Inovação.

[1] Possui graduação em Ciências Econômicas pela Universidade Estadual de Londrina (2010) e mestrado em Economia pela Universidade Estadual de Maringá (2013). Atualmente é professor colaborador do Departamento de Economia da Universidade Estadual de Londrina e doutorando pelo Programa de Ciências Econômicas da Universidade Estadual de Maringá. E-mail: angelorondina@gmail.com
[2] Professor da Universidade Estadual de Mato Grosso do Sul. E-mail: prof.mateusabrita@gmail.com
[3] Bolsista de Produtividade em Pesquisa 2. Orientador de Doutorado. Doutorado em Ciências (Economia Aplicada) pela Universidade de São Paulo, Brasil (2000). Professor Titular da Universidade Estadual de Maringá, Brasil. E-mail: jlparre@uem.br

 ISSN: 2447-9195.
Geofronter, Campo Grande, n. 3, v. 1, janeiro a junho de 2017, p. 71-95.

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

Introduction

The industry of mobile phone devices presents an oligopolistic structure, with internationalized capital companies operating in a technological frontier context. Throughout the 2000s there have been notable advances in products manufactured by firms of this industry. The high-tech cellphones in the 2000s were successively enhanced to better meet the communication needs of consumers and incorporating diverse functions than traditional communication.

The cellular phone, which dates back to the 1950s, began to be widely commercialized in the 1990s. In that decade, the prominent company was Nokia; according to Martti (2002), in 1993 the company was the first to transmit text messages via cell phone through the GSM system, and in 1998 achieved the highest worldwide market share when it overtook Motorola. Throughout the 2000s, in turn, there were considerable improvements in cellular handsets produced, as visible in so-called "generations" of mobile – in 2015, there are already cell phones of the 4th generation (4G). The improvements, however, did not occur only on existing technologies. It might also be checked the inclusion of various functions to mobile phones over the decade – examples are the inclusion of cameras, FM radio, MP3 and video players etc.[4]

In 2007, together with these incremental innovations in the physical device (hardware) of the existing cell phones, there is the inclusion of an operating system (software), enabling the connection to internet network and its use in a similar way of a personal computer. It is the genesis of the devices known as *smartphones*. In this context, the question of technological innovation gains decisive role in the performance of companies in this sector. According to Kok and Biemans (2009), the lifetime shortening of products and the high competition for the best products introduces in the agenda of the administrations of the companies the need to guide their performance through innovations.

Together with changes in the mobile devices industry products, it is possible to check also changes in the industry market structure. Leading companies in the production of mobile devices in the early 2000s (Ericsson, Motorola, Nokia) loosed ground to other emerging

[4] Viljamaa (2008), in his presentation on the influence of design in the integration of multimedia devices, presents an interesting evolution of this integration of functions in the mobile phone industry.

companies (Apple, LG, Samsung) at the end of the period. This new scenario leads even to the sale of part of those firms in the late 2000s to companies not operating in the market[5].

This study starts from the hypothesis that one of the factors responsible for this structural change of the mobile phone devices industry were the innovation strategies carried out by firms of this industry, which accounts for their different performances.

The studies about innovation begin in a more structured way in Schumpeter (1911), reveling the process of creative destruction resulting from innovations in capitalist markets. Freeman and Soete (2008, p. 25), following the line of Schumpeter in the studies of innovation, consider that the Research and Development (R&D) department of firms are the main entities responsible for social and economic change, as well as for the changes in the capitalist production, in the twentieth century. The authors consider these entities, together with the industrial production and marketing, of crucial role to the economies.

In the face of such a change in the mobile phone devices industry structure and the hypothesis about the role of innovation strategies used by the firms to explain it, one comes to the guiding question of this study: How can the different innovation strategies implemented by the firms of the industry of mobile phone devices explain the structural change in the industry?

To answer this question, the paper has as its main objective to analyze the influence of different types of innovation strategies on the business performance of the international industry of mobile phone devices in general, and Apple, Nokia and Samsung in particular. Thus, it will be used a model based on game theory, since it enables an important tool for analyzing the behavior of firms operating in strategic oligopolistic competition. This is the case of Apple, Nokia and Samsung, firms that will be taken as representative of the mobile phone industry for the 2000s.

Thus, the section following this introduction presents the performance history of the mobile phone device industry, particularly throughout the 2000s, the period considered by the study. The third section presents some aspects of game theory that will be used to develop the game model for the analyzed industry. The fourth section presents aspects related to the role of innovation, considered as a central element in the different strategies of firms from the

[5] This is the case, for example, of the purchase by Google of part of Motorola Company in January 2011; and the purchase of Nokia conducted by Microsoft in September 2013.

mobile phone device industry within the model. This model is presented in the fifth section. Lastly, the conclusions are presented.

Development of the mobile phone device industry in the 2000s

The telecommunications industry is characterized as an innovative frontier area. The mobile phone market, in particular, is characterized as an oligopoly, with large companies from different countries whose capitals are internationalized. Examples of these companies are Apple and Motorola (United States), BlackBerry (Canada), Ericsson (Sweden), Nokia (Finland), Sony (Japan), LG and Samsung (South Korea) and HTC (Taiwan).

The origin of the mobile phone (cellular phone) is related to the scientific developments of the post-War. In 1947, the development of cellular technology began in the Bell Laboratory[6], USA. In 1956, Ericsson developed the first mobile phone, called MTA Ericsson, however, with an approximate weight of 40 kg, which precluded their personal use. In 1973, Motorola develops the Motorola DynaTAC 8000X, with an approximate weight of 1 kg; the first mobile with possible personal use, and as point Brandão et al (2009) with operating permission by the US Federal Communications Commission in 1983.

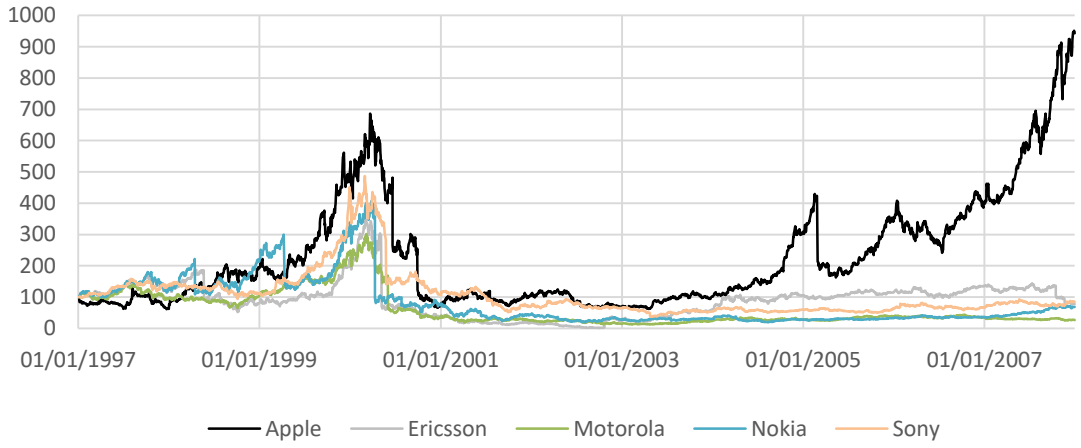
The mobile market starts then from the decade of 1980 (1979 in Sweden and Japan; 1983 in the US), and is extended to developing countries from the end of the decade – in the case of Brazil, for example, in the begging of 1990, as pointed out by Abreu and Moraes (2005). Together with other technologies, mobile telephony was considered one of the responsible for the Industrial Revolution generated by Information and Communication Technologies in the 1990s – Freeman and Soete (2008).

Throughout the 1990s, the mobile devices industry gained dimension, as evidenced by the evolution of stock prices of the companies belonging to it, shown in Figure 1. In it is observed the growth in the stock price of leading producers of mobile phones in 1997. It is worth noting the period of the called "Internet Bubble", between 1999 and 2000, with the atypical rise in stock prices of companies related to Information Technology. In addition, it is possible to verify the development over the early 2000s of Apple, related mainly to the manufacture of other products than mobile phones[7].

[6] Research and Development (R&D) laboratory of AT&T.

[7] Apple did not produce cell phones at the time, being presented in the period due to later comparisons in the smartphone market.

Figure 1: Evolution of price of shares of the mobile phone devices companies between 1997 and 2007 – Index (02/01/1997 = 100)



Source: NASDAQ (2014), NYSE (2014).

Throughout the 2000s, the mobile device, which was used mainly for the purpose of mobile communication between people, adds features that were commercialized as products from other different markets. Therefore, there is the inclusion of cameras, FM radio, MP3 reader etc. In 2007, together with these incremental innovations, there is the inclusion of a software along the existing hardware in mobile phones, enabling connection to the internet data network and its use in a similar way as a personal computer. Since then, these new phones that incorporate these possibilities are known as *smartphones*.

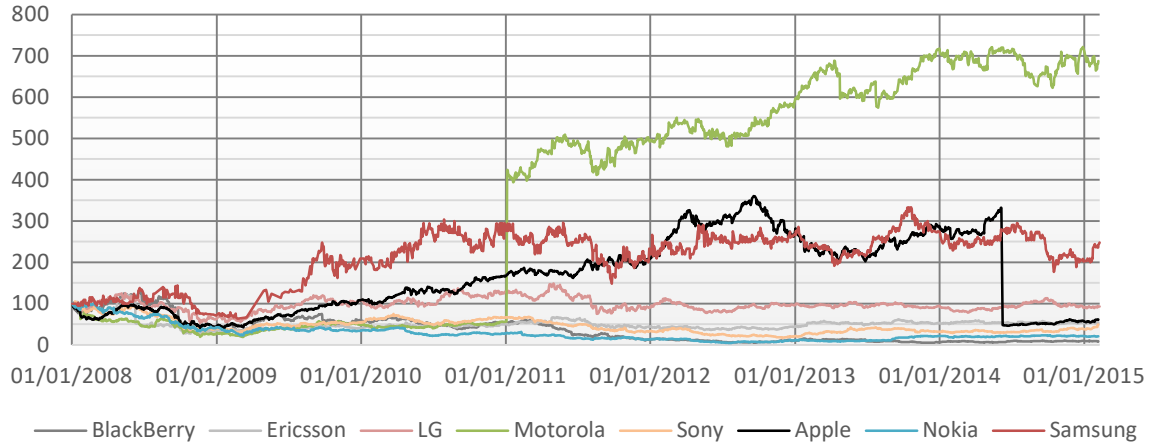
Figure 2 shows the evolution of share prices of leading companies in the mobile devices industry from 2008, the year that the production of smartphones began. It is interesting to verify the fall in the value of shares of companies such as Motorola and Nokia – considered two of the leading producers of mobile phones devices in early 2000 – in contrast to the growth in value of shares of companies like Apple and Samsung[8].

[8] It is also worth noting the rupture of Motorola and Apple series. For the former, this is due to the sale of part of the company (Motorola Mobility) to Google on January 4, 2011; Motorola prices computed from that date refer to the part of Motorola Solutions – part of the company that was not sold. Similar process was also found with Nokia in which, like Google, other major software company, Microsoft, bought its division of mobile devices on September 3, 2013, with no rupture in the series due of total company sales.
In the case of Apple, the break in the series due to a stock split process carried out on June 9, 2014.

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

Figure 2: Evolution of the price of shares of the mobile phone devices companies between 2008 and 2014 – Index (02/01/2008 = 100)



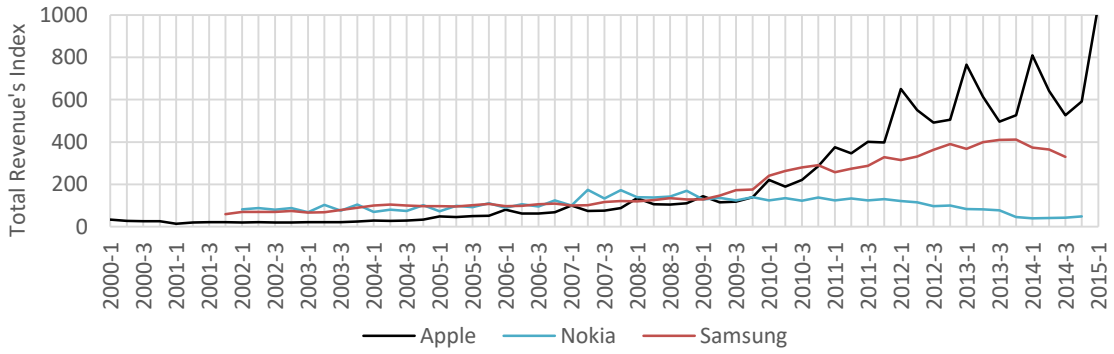
Source: NASDAQ (2014), NYSE (2014), SWB (2014), KRX (2014).

This diverse business performance transcends the stock market and also can be checked by the analysis of the evolution of the balance sheets of these companies. Figure 3 lists the evolution of revenues and net profits of three of the previous companies (Apple, Nokia and Samsung), considered companies with representative situations of performance in the considered industry, for the period between the first quarter of 2000 to the first quarter of 2015. It can be analyzed the performance differential between the three selected companies, with Nokia evidencing a declining in the revenues, while the total revenue of Apple and Samsung increased after 2007. With regard to net profits of the companies (withdrawing the costs and taxable revenue from the earnings), shown in Figure 4, there is a similar scenario, with declining net income in the case of Nokia (presenting loss in periods of 2011), and increasing profits for Apple and Samsung. It is worth noting that in the case of the latter, there is a significant difference between the performances of both too, with Apple's net profit growth with a more significant development than the one of Samsung.

GEOFRONTER

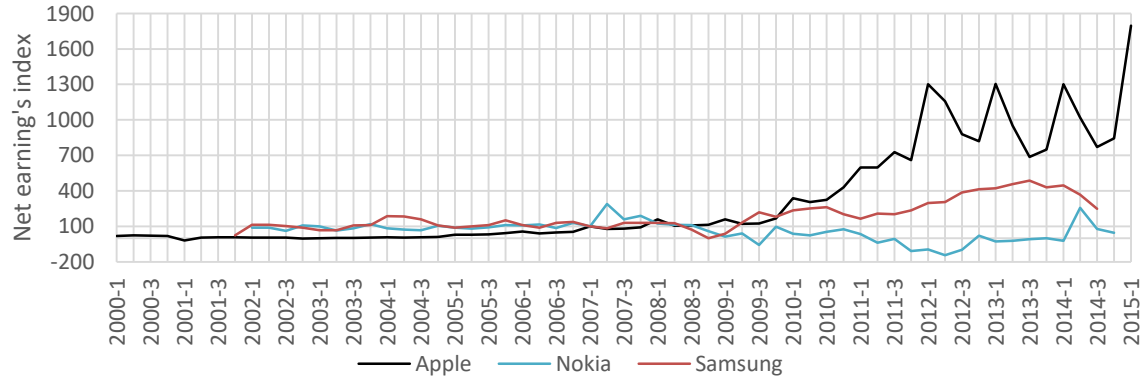
https://periodicosonline.uems.br/index.php/GEOF/index

Figure 3: Evolution of Total Revenue of selected companies from the industry of mobile phone devices between 2000 and 2014 – Index (1Q / 2007 = 100)



Source: APPLE (2014), NOKIA (2014), SAMSUNG (2014).

Figure 4: Evolution of net earnings of selected companies from the industry of mobile phone devices between 2000 and 2014 – Index (1Q / 2007 = 100)



Source: APPLE (2014), NOKIA (2014), SAMSUNG (2014).

From the data previously presented, it is clear, therefore, a performance differential between companies operating in the mobile phone devices industry. There can be many reasons for the difference in the evolution of the companies in the 2000s, especially after 2007, the year that the production of smartphone devices began. This paper presuppose the assumption that a key factor for the differential in the performance of companies in the mobile phone devices industry over the period considered was the strategy taken with regard to innovation. I.e., the different innovation strategies undertaken by companies and the effectiveness of these in an oligopolistic competitive environment explain the difference in performance of these over the period analyzed.

Thus, to analyze the different strategies undertaken by the considered representative firms of the mobile phone devices industry, it was used a game theory model. Thus, in the next sections, is sought to be presented the theoretical framework of the Games Theory and the Innovation Theory in order to enable further structuring of the model.

Game theory: a brief summary

The game theory has gained wide application in applied social sciences from the 1990s. Collaborated for this fact the delivery of the Nobel Prize in economics in 1994 to John C. Harsanyi, John F. Nash and Reinhard Selten, especially for the advance on equilibrium analysis in theory of non-cooperative games. The first – as found for example in Harsanyi (2001) – uses game theory to formalize the decision-making process of the agents in different contexts, and including the incorporation of subjective probability and strategic actions to agents. The second – as seen in Nash (1997) – uses game theory to formalize the behavior of companies operating in strategic duopolistic competition. The third consolidated the use of game theory for the analysis of dynamic strategic interactions, as seen for example in Selten (1975).

As point Kreps (1992) and Mas-Colell, Whinston and Green (1995, p. 217), game theory is divided between the strands of cooperative games between the agents and the non-cooperative games. While the first's focus is given on a set of agents, in the second the emphasis turns to the optimizer individual – which makes it a very useful tool for microeconomic theory.

The extensive representation of non-cooperative games

According to Osborne (2006), game theory presents a set of models used to understand various situations in which the players (decision maker agents) interact. Mas-Colell, Whinston and Greene (1995, p. 219) define a game as a representation of a situation where a number of players interact in a set of interrelated strategies. Thus, in order to describe a strategy interaction, it is necessary to know four elements: **i)** The players involved. **ii)** The decision rules – i.e., who moves first, what information the agents have and what are the possible actions to be undertaken by the players. **iii)** The results of the actions of the players. **iv)** The payoffs – i.e. the preferences of the players based on the possible outcomes of the

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

actions taken – in microeconomic theory, it is generally associated with the utilities functions or the process of maximization of the profit functions.

To represent an extensive non-cooperative game, according to Kreps (1992), it is necessary to include[9]:

i) A list of the finite number of players;

I.e., a list of players $i = 1.2, \dots, I$, where I is finite. In some cases, the "nature" can also act as a player.

ii) The design of the game tree, with its different nodes (initials, decision and terminals);

The game tree is defined as a set $T(t)$ of all nodes (initials, decision and terminals) in a precedence relationship ($\rightarrow$) over T. I.e., t will precede t' ($t \rightarrow t'$) if there is a sequence of arrows from t to t'.

iii) The designation of the players in each starting or decision node of the game tree;

The initial nodes are defined as $W = \{t: P(t) = \emptyset\}$, where $t\ \varepsilon\ T$, without predecessors. The terminal nodes are defined as $Z = \{t: S(t) = \emptyset\}$, where $t\ \varepsilon\ T$ without successors. The decision nodes would be the set X of the nodes, excluding the terminal nodes Z. I.e., $X = T - Z$, with $x \notin W$ and $x\ \varepsilon\ X$.

iv) ***The list of strategies available to players****;*

For each $t\ \varepsilon\ X \cup W$, i.e., each node existing at the union of the initial and decision nodes, there is a set $A(t)$ of strategies available in the node t.

v) The informational set;

The set of nodes of decision X is divided in h informational sets. I.e., there is a partition $H = \{h_1, h_2, \dots, h_n\}$ of X, wherein: (a) to t and t' that belong to the informational set h, t and t' cannot precede; (b) a single player i is assigned to the informational set h; and (c) the strategies available in the nodes of a same informational set are the same for each player – the rules do not vary in the same information set.

This definition means that may be certain h informational subsets of decision nodes where the player chooses the strategy in one of the nodes and does not know in which of the

[9] Similar definition is presented by Mas-Collel, Whinston and Greene (1995, p. 227).

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

nodes it is. In this case, are drawn dotted lines connecting all nodes in a given informational set $h \varepsilon H$. In such cases, the information is not perfect between the players.

vi) The players' payoffs

The payoffs are usually posed by the existence of an expected utility function. Usually, it is made use of the Neumann-Morgenstern utility functions type[10], U, wherein $U: \{1,2, \dots, I\} \, x \, Z \rightarrow R$ – defined as $U_i(Z)$ –, meaning that for each player i it is delimited a payoff by the U function, defined in the set of the real numbers, inserting it into the specific terminal node Z.

vii) ***The probabilities given by the players' available strategies***

I.e., there is a distribution of probabilities δ over the initial set of nodes W, so that for every $t \, \varepsilon \, X$ decision node there is a given probability distribution ρ on the set of strategies available $A(t)$.

Mas-Collel. Whinston and Greene (1995, p. 227) formalized the extensive form of a game through the collection of these elements. In a similar presentation, it is possible to pose a game in the extensive form as:

$$\Gamma_E = \{T, A, I, P(.), X(.), H, h(.), \rho(.), U\} \qquad (1)$$

Possible equilibriums of non-cooperative games

In non-cooperative games, the strategies can be said to be pure or mixed. In the first case, it is not assigned probabilities to the players' different strategies available. In the second one, there is the probability assignment by the players.

It is also capable to distinguish the kind of game in accordance with the movements of the players: simultaneously (static), in which all players move together; or sequential (dynamic), in which the players move in sequence. Other way of differentiating the kind of the game is according to the way that the information about the rules of the game is presented to the players. I.e., the game may present: complete information, where all players are as well aware of their movements as the other players; and incomplete information, in which case there is information of other players who are unknown to one player of the game. The

[10] The mathematician John von Neumann and the economist Oskar Morgenstern, beyond of releasing the basis for modern game theory, contributed to the mathematical structuring of the concept that each individual chooses an alternative according to a probability, so as to maximize its utility. Such utility functions carry thus their names. See Neumann and Morgenstern (2004).

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

differentiation of the types of games in accordance with these elements is presented in Table 1.

Table 1: Possible equilibriums in game theory

		GAME	
		STATIC	DYNAMIC
INFORMATION	COMPLETE	NASH EQUILIBRIUM	PERFECT EQUILIBRIUM IN SUBGAMES
	INCOMPLETE	NASH-BAYESIAN EQUILIBRIUM	PERFECT BAYESIAN EQUILIBRIUM

Source: Produced by the authors from Mas-Collel, Whinston and Green (1995) and Bierman and Fernandez (1998).

In this article, the mobile phone devices industry is analyzed in an already occurred period of the 2000s (*ex post*), considering that the firms act simultaneously – thus, corresponding to a static analysis. In addition, it is considered that the firms engaged in this industry do not have full information on the other. Thus, below are detailed briefly the Nash-Bayesian game type, that will be used in subsequent model.

Nash-bayesian equilibrium: harsanyi's contribution

The Nash-Bayesian equilibrium occurs in static games (where players move at the same time) and the participating players do not know all the relevant information about the other (including payoffs that will be received in the different rewards strategies of the game). It is said, therefore, that such games have incomplete information.

The presence of incomplete information, as pointed out by Mas-Collel, Whinston and Greene (1195, p. 253), would generate the need to consider the beliefs of the players on the preferences of the others players. It would also be necessary to consider the beliefs of these other players on the player's belief and, in turn, about the others' preferences, and so on, in the spirit of rationalization.

However, the above authors present that, fortunately, there is an approach to this problem that makes these considerations not needed. This approach refers to the works of Harsanyi (1968). In such, it is considered that the preferences of each player are determined by the realization of a random variable. Although only the player knows the realization of the

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

variable, *de facto*, his *ex ante* probability distribution is assumed to be of common knowledge to the players.

Thus, the "Nature" would perform the first movement, choosing the realization of this random variable. This movement determines the type of preferences of the players, with each player observing only the fulfillment of their random variables.

Once exposed the elements that structure a game in the Game Theory, is sought in the next section to analyze the elements of the theory of innovation that may point out the different strategies (of innovation) taken by the players (firms of the mobile phone devices industry) in the model considered later.

The sources of innovation and de creative distruction

The theory of innovation has as mark the studies of Schumpeter (1911). The author parts of the conception of capitalism as an evolutionary process, being by nature a system in constant economic change – not being, therefore, stationary. This economic system would have as a central element of its dynamic the change – which, in turn, would have in its base the competition of firms by innovations.

In other to justify his exposure, Schumpeter (1911) parts of the presentation of the circular flow. In this system, innovations disrupt the precursor equilibrium framework in which the economy was, generating in turn the development of new productive forces. According to the author, the sources for the innovation process are:

i. ***The introduction of a new product (radical innovation), or the improvement in the quality of existent products (incremental innovation);***

ii. ***The introduction of a new method of production, not yet previously tested in the manufacturing industry (it does not necessarily is based on a new scientific discovery, but it can occur through a new way of managing a product commercially);***

iii. ***The opening of a new market (with best marketing and sales strategies, for example);***

iv. ***The conquest of a new source of raw materials or of semi-manufactured products;***

v. ***The establishment of a new organization in an industry (such as the establishment of a monopoly position or the fragmentation of a previous monopoly position).***

 ISSN: 2447-9195.
Geofronter, Campo Grande, n. 3, v. 1, janeiro a junho de 2017, p. 71-95.

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

These industrial change processes revolutionize the economic structure by destroying the old structure and creating a new one. This progression is presented by Schumpeter (1911) as the process of *creative destruction*. Freeman and Soete (2008, p. 25), following the line of Schumpeter in the studies of innovation, consider that the Research and Development (R&D) entities in the firms are the main bodies responsible for this process of social and economic change, as for the changes of the capitalist production in the twentieth century. The authors consider these R&D entities, together with the industrial production and the marketing as of crucial importance for the world economies.

On the model considered here, it is analyzed the different strategies of innovation of the firms from the mobile phone devices industry. Thus, the sources of innovation presented by Schumpeter (1911) are grouped in two groups[11]:

i. ***Innovations by products***

In which is considered the sources generated by the firms as a result of the process of Research and Development (R&D) of new products and new methods of productions (items *i* and *ii*).

ii. ***Innovations through markets***

Considering the innovations generated because of sales and marketing of the firms (items *iii* and *iv*).

This proposed division allows the analysis of innovation strategies of the firms by the creation of a proxy for each of the two groups. I.e., it is analyzed the innovations related with the expanses of R&D of the companies (innovation by products), as those related with selling, general and administrative (SG&A) expenditures (innovation through markets).

Figure 5 shows the evolution expenditures on R&D and SG&A during the 2000s for the representative firms of the mobile phone devices industry analyzed (Apple, Nokia and Samsung). It is noticed that, after 2007, there is a fall in the index of R&D and SG&A expenditure for Nokia, with greater intensity especially after 2011. The reverse situation is verified for Apple and Samsung. I.e., the indexes has been raised during the period of

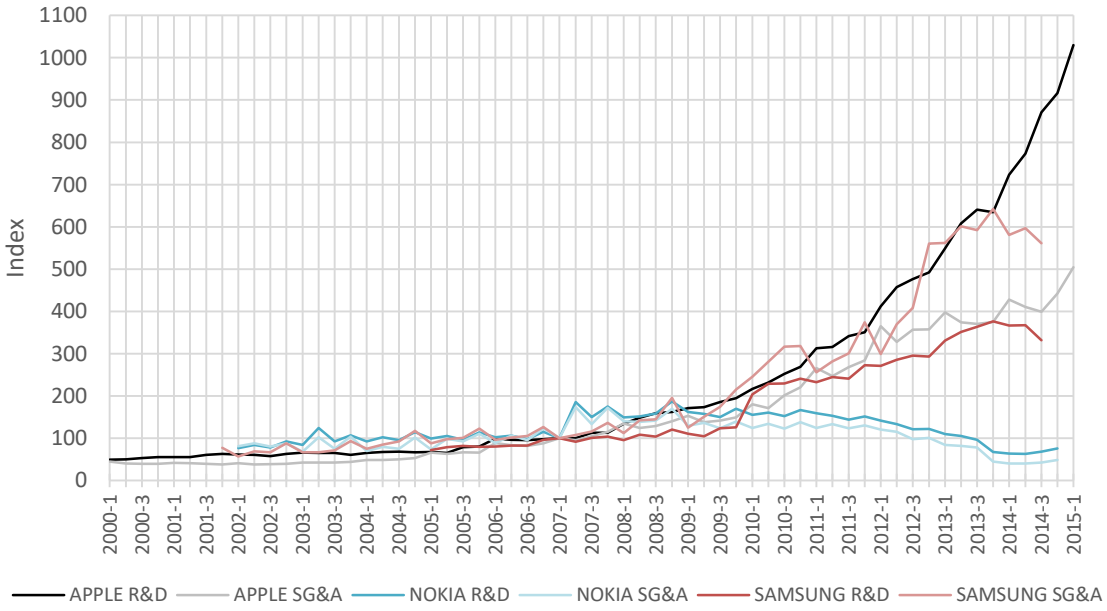
[11] The item *v* is not considered since its causality is exogenous to the firm. I.e., the changes in the industrial organization do not depend in the decisions of an individual firm alone.

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

analysis. However, for Apple, the index of R&D was superior that its SG&A index; and for Samsung the opposite case of Apple was verified.

Figure 5: Expenditures on R&D and SG&A of the companies of the mobile phone devices industry in the 2000s – Index (1Q / 2007 = 100)



Source: APPLE (2014), NOKIA (2014), SAMSUNG (2014).

The Game theory applied to the mobile phone devices industry: a nash-bayesian equilibrium model of innovative strategy decisions

Based on the goals presented, it was developed a model based on game theory to analyze the performance of the representative companies of the mobile phone devices industry throughout the 2000s regarding their innovative development. So, the model parts of the assumption that the performance of the companies differed over the period analyzed due to the different innovative strategies adopted by the representative companies.

5.1 MODEL ASSUMPTIONS

The model has the following characteristics:

i. ***There are two players, the company 1 (Apple) and company 2 (Nokia in the application I; Samsung in the application II)***

ii. ***Each company has three possible actions:***

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

a. *Innovate by products (IP) – with higher spending on R&D vis-à-vis SG&A. In this case, the hypothesis is that the company focuses more on developing products with new technologies to attract consumers.*
b. *Innovate through markets (IM) – with higher spending on SG&A vis-à-vis R&D. The hypothesis in this case is that the company focuses more on expanding the existent markets through expenditures in marketing and expanding its sales.*
c. *Exit the market (E).*

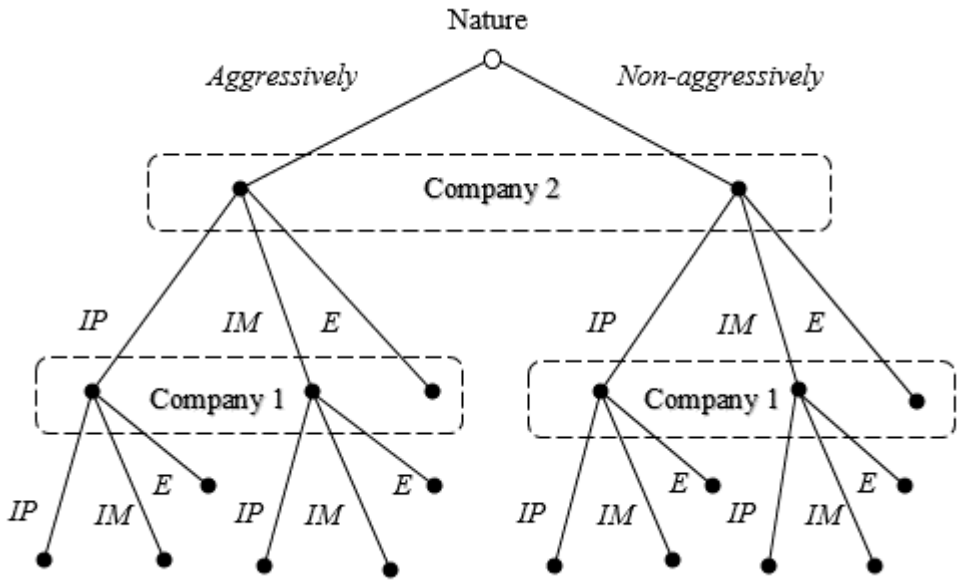
iii. The company 1 (Apple) can enter in the market according to two types:

a. *Aggressively, with intensive investment in product innovation (and, therefore, higher expenditure on R&D).*
b. *Non-aggressively, with investment in product innovation relatively less intensively.*

iv. Following the approach of Harsanyi (1968), the "Nature" makes the first move, determining the type of company 1.

The equilibrium of the game is configured, thus, as a Nash-Bayesian equilibrium and its game tree may be represented as in Figure 6.

Figure 6: Game tree of the model



Source: Elaborated by the authors.

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

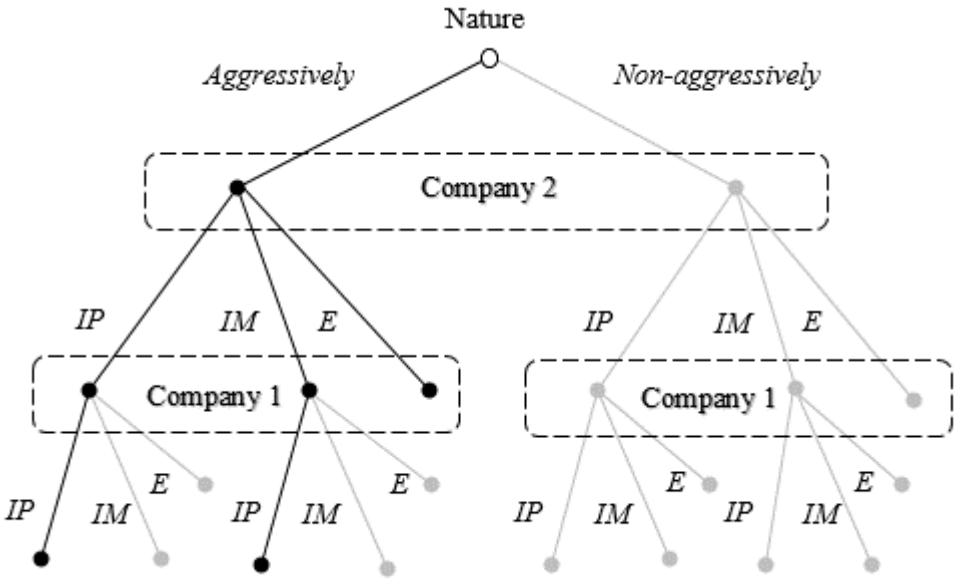
Thus, Nature performs the first movement determining the kind of innovative type of the company 1 – I.e., if it is aggressive or non-aggressive. Then, the company 2 takes its action in the game, i.e., innovates through markets, by products or exit the market. At the same time, the company 1 also conducts its action, i.e., innovates through markets, by products or exit the market.

Mobile phone devices industry performance based on the model

Based on the data presented in sections 1 and 4, it is possible to use the developed model in order to analyze the scenario in the mobile phone devices industry since 2007. As previously presented, from that year the production of the smartphone by Apple, and the other companies in the market insert themselves in the market soon after. Thus, with the *ex post facto* data, it is analyzed the behavior of the companies based on the model suggested.

In the period analyzed, Apple inserts itself in the market with intense innovation, presenting higher expenditures in R&D *vis-à-vis* SG&A. In the model, a way to illustrate such facts is presenting Apple's strategy to be *Aggressive* and *Innovating by products* (*IP*). Therefore, one may incorporate this information in the previous game, removing the strategies that are not expressed in the analyzed scenario, as shown in Figure 7.

Figure 7: Model game tree based on Apple's data



Source: Elaborated by the authors.

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

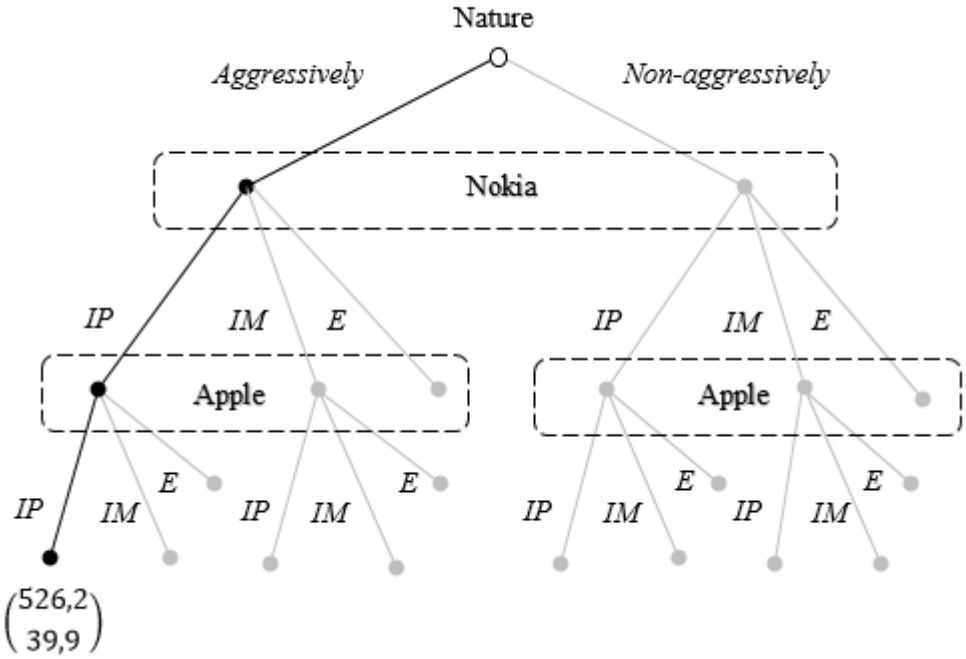
Going forward, there are three possible terminal nodes: (*Aggressive* → *IP*); (*Aggressive* → *IM* → *IP*); and (*Aggressive* → *E*). The third terminal node can also be removed, since all companies analyzed remained in the market during the period analyzed.

Next, it is tried to incorporate the *ex post facto* data for the other two companies of the model. In the case I, it is incorporated the strategy verified by Nokia's data. In the case II, it is incorporated the strategy verified by Samsung's data.

5.2.1 Case I: Apple and Nokia

For the period after 2007, the expenditure on R&D undertaken by Nokia always showed superior growth than those on SG&A. Thus, it is suggested that the strategy adopted by Nokia in the period was to *innovate by products* (*IP*). It is possible to present this information on the game tree as followed in Figure 8.

Figure 8: Model game tree based on Apple and Nokia's data



Source: Elaborated by the authors.

Thus, the equilibrium for the model is (*Aggressive* → *IP* → *IP*). The payoff on that terminal node can be displayed based on the average of the net profit of the companies for the

GEOFRONTER

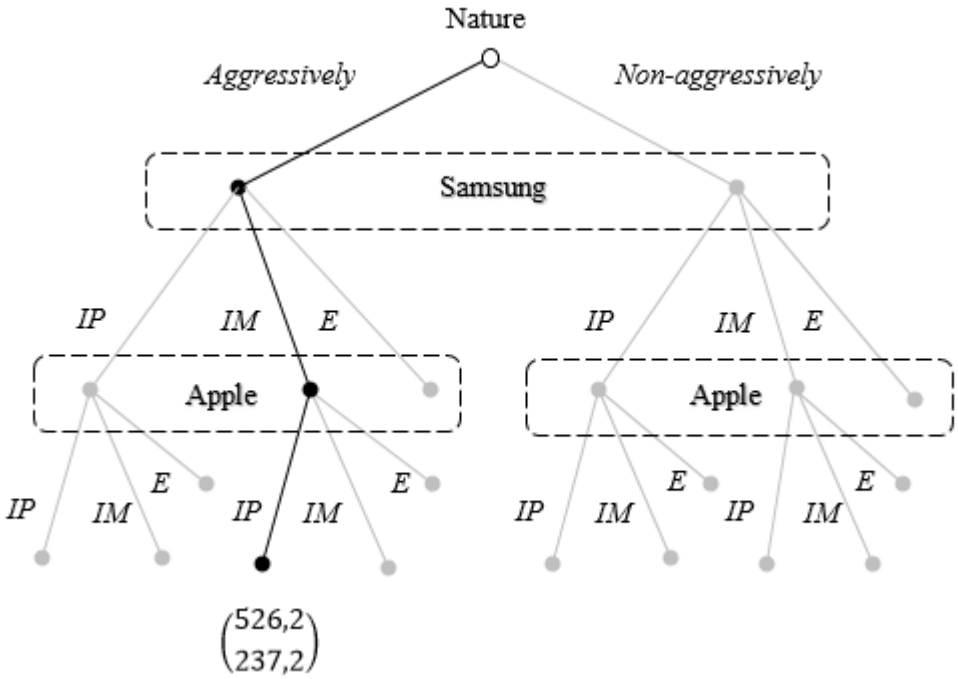
https://periodicosonline.uems.br/index.php/GEOF/index

period from the first quarter of 2007 to the third quarter of 2014[12]. In the case of Apple, the average net income for the period was 526,2, while for Nokia was 39,9.

5.2.2 Case II: Apple and Samsung

As shown in section 4, in the case of Samsung, between 2007 and 2014, its expenditures on SG&A showed superior growth than those on R&D. It is, then, suggested that the strategy adopted by Samsung was to *innovate through markets* (*IM*). Thus, the game with this information can be shown in Figure 9.

Figure 9: Model game tree based on Apple and Samsung's data



Source: Elaborated by the authors.

Similar to the case of Nokia's analysis, there is a single terminal node possible, with the game's equilibrium being (*Aggressive* → *IM* → *IP*). The payoffs, measured in terms of average of the net profit for the companies between the first quarter of 2007 and the third quarter of 2014 show the value of 526,2 for Apple and 237,2 for Samsung.

[12] The values of the payoffs are presented in index (100 = 1Q/2007), since the currencies accounted on the earnings release of the companies differ.

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

Conclusion

The objective of this study was to demonstrate the influence of different types of innovation in the performance of companies in the mobile phone devices industry through a model based on the game theory. In section 5 was presented a theoretical model with a Nash-Bayesian equilibrium and was analyzed the final equilibrium resulting from that model and from the data of the companies for the first quarter of 2007 to the third quarter of 2014.

In can be observed that, starting from Apple innovating by products intensively (through a higher growth in expenditure on Research and Development (R&D) than on Selling, General and Administrative (SG&A)), the competitor's strategy to also innovate by products had a worse outcome than that of innovate through markets (with a higher expenditure in SG&A than on R&D).

This is illustrated through a static-comparative analysis of the two cases shown. In the first case, Nokia competes in the market through innovation by products; in the second one, Samsung competes with innovation through markets. With the assistance of the data of section 4, it can be seen that, while in the case I the average net profit for the period was 39,9, in the case II the average was 237,2.

Therefore, assuming the central importance of the innovative character of the companies to persist in an oligopolistic market, the model helps to understand the context of the mobile phone devices industry in the 2000s. I.e., the model contributes to verify the reasons that led to the decline of the total earnings and the net profits of Nokia, while Samsung and Apple presented an opposite scenario. The model also helps in understanding the restructuration verified at the end of the 2000s for the industry, with the merging of companies from outside of the market with those of worst performance in the market – Nokia, Motorola – relatively to those that had better performance – Apple, Samsung. In can by concluded, thus, that companies operating in an oligopoly market should have a special concern to their innovative strategies to remain operative in dynamic markets, as specifically verified for the mobile phone devices industry.

Finally, it is noteworthy that such models have inherent limitations, given the complexity of the reality of the markets. However, the model raises the possibility of new studies taking as a base the advances from the analysis of the present study.

References

ABREU, Leonardo Marques de; MORAES, Anamaria de. **Usabilidade de telefones celulares com base em critérios ergonômicos**. 2005. 294 f. Dissertação (Mestrado) – Pontifícia Universidade Católica do Rio de Janeiro, Departamento de Artes e Design, 2005.

APPLE – Earnings Releases. Available at: <http://investor.apple.com/financials.cfm>. Accessed in: 28/05/2015.

BIERMAN, H. Scott; FERNANDEZ, Luís. **Game theory with economic applications.** Massachusetts: Addison-Wesley, 1998.

BRANDÃO, Francisco et al. **A Revolução das Comunicações Móveis: Evolução dos serviços nas redes móveis.** Relatório (Mestrado em Engenharia Eletrotécnica e Computadores) – Faculdade de Engenharia da Universidade do Porto, Porto, 2009.

FREEMAN, Christopher; SOETE, Luc. **A economia da inovação industrial.** Campinas: Editora da Unicamp, 2008.

HARSANYI, John C. Games with incomplete information played by Bayesian players. *Management Science* v. 14, p. 159-182; 320-334; 486-502, 1968.

_____. **Papers in game theory.** Nova York: Springer, 2001.

KOK, R.; BIEMANS, W. Creating a market-oriented product innovation process: a contingency approach. Technovation, v. 29, n. 8, p. 517-526, 2009.

KREPS, David M. **Game Theory and Economic Modelling.** Nova York: Oxford University Press, 1992.

KRX, Korea Exchange. Available at: <http://eng.krx.co.kr/>. Accessed in: 28/05/2015.

MAS-COLLEL, Andreu; WHINSTON, Michael D.; GREEN, Jerry R. **Microeconomic Theory.** Nova York: Oxford University Press, 1995.

MARTTI, Haikio. Nokia: the inside story. New York: Pearson, 2002.

NASDAQ, National Association of Securities Dealers Automated Quotations. Available at: <http://www.nasdaq.com/quotes/>. Accessed in: 28/05/2015.

NASH, John F. **Essays on game theory**. Nova Jersey: Princeton University Press, 1997.

NEUMANN, John von; MORGENSTERN, Oskar. **Theory of games and economic behavior.** Nova Jersey: Princeton University Press, 60 ed., 2004.

NOKIA – Earnings Releases. Available at: <http://company.nokia.com/en/investors/financial-reports/results-reports>. Accessed in: 28/05/2015.

https://periodicosonline.uems.br/index.php/GEOF/index

NYSE, New York Stock Exchange. Available at: <https://www.nyse.com/data>. Accessed in: 28/05/2015.

OSBORNE, Martin J. **Strategic and extensive games [Working Paper].** Toronto: University of Toronto, 2006.

SAMSUNG – Earnings Releases. Available at: <http://www.samsung.com/us/aboutsamsung/investor_relations/financial_information/business_report.html>. Accessed in: 28/05/2015.

SCHUMPETER, J. A. **Teoria do desenvolvimento econômico:** uma investigação sobre lucros, capital, crédito, juro e ciclo econômico. First Ed: 1911. São Paulo: Abril Cultural, 1982.

SELTEN, Reinhard. **Reexamination of the perfectness concept for equilibrium points in extensive games**. International journal of game theory. Berlin: Springer Berlin Heidelberg, v. 4, p. 25-55, 1975.

SWB, Börse Stuttgard. Available at: <https://www.boerse-stuttgart.de/>. Accessed in: 28/05/2015.

VILJAMAA, Timo-Pekka. **Unified media functions for mobile multimedia devices**. Proceedings of the International Conference on Mobile Technology, Applications, and Systems. ACM, 2008.

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

APPENDIX

Table A.1: Data from the companies of the mobile phone devices industry from 1Q/2000 to 1Q/2015.

Data	APPLE (US$ Billions)					NOKIA (€ Billions)					SAMSUNG (₩ Trillions)				
	Net Sales	Gross Profit	Net profit	R&D	SG&A	Net Sales	Gross Profit	Net profit	R&D	SG&A	Net Sales	Gross Profit	Net profit	R&D	SG&A
2000-1	2.343	0.607	0.183	0.090	0.319	-	-	-	-	-	-	-	-	-	-
2000-2	1.945	0.549	0.233	0.092	0.287	-	-	-	-	-	-	-	-	-	-
2000-3	1.825	0.543	0.200	0.097	0.278	-	-	-	-	-	-	-	-	-	-
2000-4	1.870	0.467	0.170	0.101	0.282	-	-	-	-	-	-	-	-	-	-
2001-1	1.007	-0.021	-0.195	0.102	0.297	-	-	-	-	-	7.234	1.287	1.287	0.000	1.269
2001-2	1.431	0.385	0.043	0.101	0.292	-	-	-	-	-	-	-	-	-	-
2001-3	1.475	0.434	0.061	0.111	0.281	-	-	-	-	-	-	-	-	-	-
2001-4	1.450	0.437	0.066	0.116	0.268	-	-	-	-	-	8.483	1.820	0.403	-	1.751
2002-1	1.375	1.375	0.038	0.113	0.289	7.014	2.7700	0.863	0.703	0.781	9.930	3.380	1.910	-	1.280
2002-2	1.495	0.409	0.040	0.111	0.270	6.935	2.8833	0.862	0.779	0.844	9.940	3.420	1.920	-	1.550
2002-3	1.429	0.391	0.032	0.106	0.272	7.224	2.7007	0.610	0.718	0.770	9.920	3.270	1.730	-	1.500
2002-4	1.443	0.381	-0.045	0.116	0.280	8.843	3.3511	1.046	0.852	0.844	10.720	3.500	1.500	-	1.990
2003-	1.472	0.406	-0.008	0.121	0.299	6.773	2.6	0.977	0.774	0.655	9.600	2.850	1.130	-	1.500

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

1							16								
2003-2	1.475	0.418	0.014	0.119	0.300	7.019	2.9870	0.624	1.144	0.985	9.840	2.820	1.130	-	1.500
2003-3	1.545	0.428	0.019	0.120	0.299	6.874	2.7700	0.823	0.855	0.723	11.260	3.650	1.840	-	1.600
2003-4	1.715	0.456	0.044	0.111	0.314	8.789	3.8445	1.168	0.987	1.000	12.890	4.740	1.860	-	2.110
2004-1	2.006	0.536	0.063	0.119	0.343	6.625	2.6822	0.816	0.855	0.665	14.410	5.700	3.140	-	1.690
2004-2	1.909	0.530	0.046	0.123	0.345	6.640	2.5500	0.712	0.945	0.764	14.980	5.640	3.130	-	1.910
2004-3	2.014	0.559	0.061	0.125	0.354	6.939	2.5229	0.660	0.880	0.717	14.340	4.830	2.690	-	2.090
2004-4	2.350	0.634	0.106	0.122	0.379	9.063	3.3733	1.019	1.053	0.977	13.895	4.183	1.830	-	2.650
2005-1	3.490	0.996	0.295	0.123	0.470	7.396	2.7399	0.863	0.919	0.702	13.812	4.136	1.498	0.725	1.986
2005-2	3.243	0.968	0.290	0.119	0.447	8.059	2.8887	0.799	0.971	0.949	13.590	3.860	1.690	0.792	2.210
2005-3	3.520	1.044	0.320	0.145	0.472	8.403	2.8333	0.881	0.885	0.886	14.540	4.400	1.880	0.819	2.270
2005-4	3.678	1.035	0.430	0.147	0.470	10.333	3.5223	1.073	1.050	1.059	15.520	4.910	2.560	0.797	2.770
2006-1	5.749	1.564	0.565	0.182	0.632	9.507	3.2244	1.048	0.946	0.853	13.959	3.781	1.884	0.805	2.167
2006-2	4.359	1.297	0.410	0.176	0.592	9.813	3.2400	1.140	0.981	1.019	14.108	3.711	1.509	0.827	2.293
2006-3	4.370	1.325	0.472	0.175	0.584	10.100	3.1222	0.845	0.905	0.919	15.216	4.221	2.187	0.833	2.371
2006-4	4.837	1.412	0.546	0.179	0.624	11.701	3.7933	1.273	1.065	1.189	15.689	4.900	2.346	0.965	2.848
20	7.1	2.2	1.004	0.18	0.7	9.856	3.	0.979	0.92	0.962	14.3	3.44	1.69	1.00	2.2

 ISSN: 2447-9195.
Geofronter, Campo Grande, n. 3, v. 1, janeiro a junho de 2017, p. 71-95.

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

07-1	15	20		4	14		262		5		86	4	9	8	61
2007-2	5.264	1.849	0.770	0.183	0.680	12.587	3.916	2.828	1.716	1.669	14.633	3.343	1.423	0.920	2.433

Table A.1: Data from the companies of the mobile phone devices industry from 1Q/2000 to 1Q/2015.

Data	APPLE (US$ Billions)					NOKIA (€ Billions)					SAMSUNG (₩ Trillions)				
	Net Sales	Gross Profit	Net profit	R&D	SG&A	Net Sales	Gross Profit	Net profit	R&D	SG&A	Net Sales	Gross Profit	Net profit	R&D	SG&A
2007-3	5.410	1.995	0.818	0.208	0.746	12.898	4.426	1.563	1.386	1.277	16.681	4.681	2.191	1.017	2.615
2007-4	6.217	2.090	0.904	0.207	0.823	15.717	5.700	1.835	1.620	1.652	17.477	4.861	2.212	1.044	3.078
2008-1	9.608	3.332	1.581	0.246	0.960	12.660	4.527	1.222	1.375	1.343	17.107	4.687	2.188	0.959	2.533
2008-2	7.512	2.474	1.045	0.273	0.886	13.151	4.424	1.103	1.396	1.328	18.139	5.105	2.142	1.089	3.212
2008-3	7.464	2.600	1.072	0.292	0.916	12.237	4.359	1.087	1.466	1.361	19.256	4.295	1.219	1.047	3.271
2008-4	7.895	2.739	1.136	0.298	0.999	12.662	4.063	0.576	1.731	1.632	18.450	3.485	-0.022	1.214	4.423
2009-1	10.167	3.532	1.605	0.315	1.091	9.274	2.903	0.122	1.500	1.242	18.566	2.976	0.619	1.112	2.829
2009-2	8.163	2.971	1.205	0.319	0.985	9.912	3.277	0.380	1.458	1.307	21.020	4.462	2.254	1.055	3.399
2009-3	8.337	3.023	1.229	0.341	1.010	9.810	3.061	-0.559	1.386	1.187	24.862	6.706	3.723	1.242	3.936
2009-4	9.870	3.614	1.665	0.358	1.063	11.988	4.073	0.948	1.565	1.342	25.325	7.226	3.054	1.266	4.856
2010-1	15.683	6.411	3.378	0.398	1.288	9.522	3.078	0.349	1.433	1.194	34.638	11.630	3.994	2.053	5.541
2010-2	13.499	5.625	3.074	0.426	1.220	10.003	3.071	0.227	1.483	1.291	37.892	13.366	4.277	2.306	6.356
2010-3	15.700	6.136	3.253	0.464	1.438	10.270	2.941	0.529	1.407	1.180	40.229	14.212	4.455	2.313	7.148
2010-4	20.343	7.512	4.308	0.494	1.571	12.651	3.727	0.745	1.540	1.327	41.871	12.756	3.420	2.427	7.197
2011-1	26.741	10.298	6.004	0.575	1.896	10.399	3.074	0.344	1.468	1.190	36.985	10.931	2.785	2.344	5.791

GEOFRONTER

https://periodicosonline.uems.br/index.php/GEOF/index

2011-2	24.667	10.218	5.987	0.581	1.763	9.275	2.832	-0.368	1.416	1.283	39.439	12.612	3.506	2.464	6.374
2011-3	28.571	11.922	7.308	0.628	1.915	8.980	2.509	-0.068	1.327	1.186	41.274	13.520	3.442	2.429	6.799
2011-4	28.270	11.380	6.623	0.645	2.025	10.005	2.904	-1.072	1.401	1.253	47.304	15.795	4.001	2.743	8.458
2012-1	46.333	20.703	13.064	0.758	2.605	7.354	2.034	-0.929	1.309	1.157	45.271	15.132	5.049	2.728	6.767
2012-2	39.186	18.564	11.622	0.841	2.339	7.542	1.781	-1.410	1.231	1.107	47.597	17.626	5.193	2.873	8.359
2012-3	35.023	14.994	8.824	0.876	2.545	7.239	1.991	-0.959	1.119	0.935	52.177	20.188	6.565	2.976	9.219
2012-4	35.966	14.401	8.223	0.906	2.551	8.041	2.584	0.202	1.123	0.965	56.059	21.506	7.039	2.956	12.669
2013-1	54.512	21.060	13.078	1.010	2.840	5.852	1.839	-0.272	1.011	0.805	52.870	21.490	7.150	3.330	12.710
2013-2	43.603	16.349	9.547	1.119	2.672	5.695	1.907	-0.227	0.972	0.786	57.460	23.120	7.770	3.540	13.590
2013-3	35.323	13.024	6.900	1.178	2.645	5.662	1.795	-0.091	0.891	0.747	59.080	23.560	8.240	3.660	13.390
2013-4	37.472	13.871	7.512	1.168	2.673	3.476	1.478	-0.018	0.620	0.429	59.280	22.830	7.300	3.790	14.520
2014-1	57.594	21.846	13.072	1.330	3.053	2.664	1.216	-0.229	0.589	0.382	53.680	21.630	7.570	3.690	13.140
2014-2	45.646	17.947	10.223	1.422	2.932	2.942	1.294	2.510	0.580	0.388	52.350	20.680	6.250	3.700	13.490
2014-3	37.432	14.735	7.748	1.603	2.850	3.324	1.478	0.750	0.626	0.404	47.450	16.740	4.220	3.340	12.680
2014-4	42.123	16.009	8.467	1.686	3.158	3.802	1.654	0.445	0.698	0.465	-	-	-	-	-
2015-1	74.599	29.741	18.024	1.895	3.600	-	-	-	-	-	-	-	-	-	-

Source: APPLE (2014), NOKIA (2014), SAMSUNG (2014).

Recebido em 08de fevereiro de 2017.
Aceito em 03 de março de 2017.