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FELIPE DE MORAES BOFF

GOOGLE, APPLE AND MICROSOFT: STUDY OF COMPETITIVE STRATEGIES IN THE EARLY 21ST CENTURY SOFTWARE INDUSTRY

Porto Alegre
2013

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Monografia apresentada ao Departamento de Ciências Econômicas da Faculdade Ciências Econômicas da Universidade Federal do Rio Grande do Sul como requisito parcial para obtenção do grau de Bacharel

Orientador: Prof. Dr. Jorge Paulo de Araújo

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As Aristotle said, the University is the place where people know how to learn and learn how to know. Aristotle's Metaphysic associates sight with knowledge, and knowledge with knowing how to learn and knowing how to teach. I inherit the will to learn from my father, Paulo Francisco Boff, who told me stories about Emperor Nero and the Roman Empire and taught me basic school mathematics. However, I learned how to transmute will into knowledge from my mother, Irenita de Moraes Boff, whose fierce determination never failed to teach me that the pursue of life goals was mine by right. I am deeply thankful for all the emotional and financial support given by her. Without my family support I would not be able to study in one of the best Universities in Brazil.

A reason for being, is to have a justification for existence, to have a meaning. My life would never have been so cheerful and meaningful if was not for my beloved Laura. Her kind words and smiles helped me through thick and thin during this period of University.

Whether the subject of our digression is technology, economy, international relations, medicine, philosophy, history or music Felipe Sebben and I are always exchanging knowledge. This long lasting friendship must be acknowledged not because without Sebben's effort the current work ought to have had a not so focused thorough review, yet because true friends are a gemstone hard to find. Another true friend that must be acknowledged is Eduardo Simões Lopes Gastal whose advice and knowledge about computer science were always at my disposal.

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"As the century closed, the world became smaller. The public rapidly gained access to new and dramatically faster communication technologies. Entrepreneurs, able to draw on unprecedented scale economies, built vast empire. Great fortunes were made. The government demanded that these powerful new monopolists be held accountable under antitrust law. Every day brought forth new technological advances to which the old business models seemed no longer to apply. Yet, somehow, the basic laws of economics asserted themselves. Those who mastered these laws survived in the new environment. Those who did not failed"
(VARIAN; SHAPIRO, 1998, p. 1).

ABSTRACT

This work reviews the very brief history of the software industry, dividing it into three types of products — software contractors, corporate software products, and mass-market software. Here I demonstrate that mass-market software producers face an oligopolistic market, and I ask whether static oligopoly theory is suitable to analyse behaviour of firms when producing an operating system. Therefore, throughout this work, I formally analyse the strategic competition for market share, concerning three touchstone models of oligopoly theory — Cournot, Bertrand, and Stackelberg's.

Google, Apple, and Microsoft produced, in the early 21st century, mobile operating systems that are perfect substitutes. However, in their advertisements, these three giant mass-market software producers signalise their products as dissimilar. This work demonstrates that the core functions and performance of these operating systems are indeed very alike, and that consumers make purchase decisions considering the perceived quality as a variable of choice. With these results, I describe hypothetical strategic behaviour of the producers and their unfolding results.

Key-words: Cournot duopoly. Bertrand and Stackelberg. Oligopoly. Software Industry. C7. C72. D2. D23. L. L12. L13. L15.

RESUMO

Este trabalho analisa uma breve história da indústria de software dividindo-a em três tipos de empresas — desenvolvedoras de custom-software, desenvolvedores de software corporativo e desenvolvedores de software de mercado de massa. Será demonstrado, neste trabalho, que os produtores de software de mercado de massa enfrentam uma estrutura de mercado oligopolista. O problema de pesquisa abordado consiste em perguntar se a teoria estática de oligopólio é adequada para analisar o comportamento das empresas que produzem um sistema operacional. Portanto, ao longo deste trabalho, é formalmente analisada a competição estratégica a partir de três modelos referência na teoria do oligopólio — Cournot, Bertrand e Stackelberg.

Google, Apple e Microsoft produzem, no início do século 21, sistemas operacionais que são substitutos perfeitos. No entanto, no mundo real, estes três gigantes produtores de software de mercado de massa sinalizam seus produtos como diferentes. Este trabalho demonstra que as principais funções e desempenho dos referidos sistemas operacionais são realmente muito parecidos. Além disso, encontra-se que os consumidores compram estes produtos utilizando como variável de escolha — a qualidade percebida. Finalmente, considerando o conjunto de estratégias dos produtores demonstrar-se-á resultados que emergem de tais escolhas.

Palavras-chaves: Duopólio de Cournot. Bertrand e Stackelberg. Oligopólio. Indústria de Software. C7. C72. D2. D23. L. L12. L13. L15.

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INTRODUCTION

The study of oligopolistic industries lies in the heart of the field of industrial organization. The study of the firm's strategic behaviour, within industries, led to both theoretical and empirical evidences, producing antitrust and regulation policies. Moreover, the consequences derived from such studies empowers firms to better understand how changes in the environment do not affect basic economic principles. According to Shapiro (1989, p. 330), the term oligopoly was coined by Sir Thomas Moore *Utopia* (1516), who noted that prices need not fall to competitive levels simply due to the presence of more than a single supplier.

Throughout this work, I formally analyse the strategic competition for market share, concerning three touchstone models of oligopoly theory — Cournot, Bertrand, and Stackelberg's. In addition, I cover some important historical facts that echoed on the mass-market software business model, for instance, antitrust cases whereas their aftermaths implied on a less aggressive behaviour by market leaders such as Microsoft and IBM. The focus on strategic competition for market share is based on the main contributions on oligopoly theory in the course of the last two centuries. The benchmark model of Cournot, published in 1838, was an inspiration, promoting the emergence of a fields of study in economic theory. Also, this work shows why it is important to divide the software industry into three different sectors in order to better analyse the distinctive business models pursued by Google, Apple and Microsoft. To conclude, I define why competition among these mass-market software firms produce an oligopolistic market.

In the research problem broached in this work I ask whether static oligopoly theory is suitable to analyse firm behaviour when producing an operating system. Thus, such software development by Google, Apple and Microsoft consists in a niche of the mass-market software industry. My *first hypothesis* concerns with a recent expansion of market-share led by Apple's smartphone, the iPhone. Since Apple's market entrance, quantity competition changed strategic positioning in the software industry. A *second hypothesis* is developed in this work, considering Microsoft's strategic choice. The Redmond firm is playing tough, showing signs of its commitment through contracts. Also, Microsoft strategic behaviour resembles that of the market-shares solution, which consists on sustaining a fixed market share regardless of what the competition does. This work also includes hypothetical assumptions about consumers, goods and the producers of operating systems. Taking into account the three benchmark models of oligopoly theory and their predictions, I consider the three operating systems involved in this work as perfect substitutes, i.e. there is no product differentiation. Therefore, consumers choose between operating systems, considering the perceive quality as a variable of choice. Even though the products being considered are perfect substitutes, through the length of this work are es-

tablished the unfolding consequences for a market whose products are not perfect substitutes. In the real world, these three giant mass-market software producers signalise their products as dissimilar, though the core functions and performance are indeed very alike.

Geoffrey e Reny (2011) defines a firm as an entity created by individuals seeking a specific purpose. This so called firm acquire inputs and combine them in order to produce output.

> "Inputs are purchased on input markets and these expenditures are the firm's costs. Output is sold on product market and the firm earns revenue from these sales. Profit maximization is the most common answer economists give and asked about the motives behind firm behaviour. However, economists have thought of other motivation like sales, market share or even prestige maximisation. The tenacity for the profit maximisation behaviour have both empirical and theoretical points of view. An empirical point of view is that profit maximisation behaviour leads to prediction of firm behaviour which are time and again borne out by evidence. From a theoretical point of view, there is first the virtue of simplicity and consistency with the hypothesis of self-interest utility maximisation on the part of consumers. Also, many alternative hypothesis, such as sales or market-share maximisation, may be better viewed as short-run tactics in a long-run, profit maximising strategy rather than as ultimate objectives in themselves" (GEOFFREY; RENY, 2011, p. 126).

Like the hypothesis of utility maximisation for consumers, profit maximisation is the single most robust and compelling assumption we can make as we begin and ultimately predict firm behaviour (GEOFFREY; RENY, 2011).

Hypothetical strategic behaviour for Google is to maximise profit, seeking a set of tactics concerning not charging hardware manufactures to adopt their operating system. This free-of-charge policy is intended to increase the consumer base due to the reduction in variable costs to the hardware assemblers of mobile devices. An increase in the installed base of consumers is directly correlated with Google's revenue stream: advertisement. Revenue stream from advertisement is depicted in the Table B.1 at Appendix C of this work. Apple's hypothetical strategic behaviour follows a less aggressive price competitiveness due to their very large installed consumer base, which is a consequence of Apple's pioneering operating system. Apple's operating system is considered the state of the art in software development for mobile devices. Finally we have Microsoft's hypothetical strategic behaviour, that gives signs of tough commitments formalized in contracts and also consists of maintaining a fixed market share no matter what the competition does. Furthermore, Google, Apple and Microsoft try, by all means, to lock consumers in their operating system. This is due to the fact that while consumers prefer the ability to comparison-shop and to switch easily to another product, producers fear this ability — and have incentives to subtly tweak their products to make it difficult to do so (KAHIN; VARIAN, 2000, p. 16).

1 LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

1.1 Brief history on Oligopoly Theory

Even before the release of Adam Smith's most famous book, *Wealth of Nations*, the nature study of market competition was object of scientific scrutiny. Yet, in Smith (1776) the question about what kind of forces interact and build the market received a different answer. In Smith (1776) was coined that an invisible hand would set the market at its equilibrium. In a perfectly competitive market, price is established at equilibrium point between supply and demand. This means that an individual firm is not capable of setting a different price from its competitors, otherwise it would see its profits falling. Hence, firms are price takers, meaning that they have to set their prices equal to current market price. In this market there are many firms producing an homogeneous good and production level is determined when a firm behaves maximizing its profits:

$$\max \pi_i = p(Y)y_i - C_i(y_i). \tag{1.1}$$

This equation only demonstrates that when in a purely competitive market, firms maximize their profit. As a consequence, firm profit is the difference between revenue, $p(Y)y_i$, and total production cost, $C_i(y_i)$. In Equation 3.1, Y represents the total amount of good being produced (industry output), while y_i is firm$i$'s output, and p is the price at market equilibrium.

As economic theory developed through time, new fruitful fields of studies have emerged, building more complex frameworks when analysing firms strategic behaviour. Alfred Marshall (1842-1924), an economist and mathematician who was Britain's major exponent of Cambridge Schools' second generation, had been influenced by many authors such as Cournot, Von Thünen and Bentham. Marshall's main contributions regarding economical thought were published in his master piece *Principles of Economics*, first time published in 1890. In Marshall (1920) he set himself to write economic theory on a more hard science basis. Marshall (1920) stated that behind demand is the marginal utility (expressed on demand side prices), and behind supply there are producers' effort and marginal sacrifice (reflected on supply side prices). Furthermore, when monetary production costs of two goods are the same, so are real costs. Sandroni (1999) stated that Marshall further developed the consumers' surplus concept. This was an early idea of Jules Dupuit, a French engineer of the nineteenth century, known in economic literature for his work on marginal cost pricing and cost-benefit analysis (EKELUND, 1968, p. 462). Consumers' surplus measures the satisfaction excess involved when one pays less than its maximum willingness to pay for a good. Marshall (1920) comments on earlier works on mathematical economics follow, in order to keep a track of the major contributions to theories

of oligopoly. The brief history of oligopoly theory starts with the first formal model of duopoly developed by Antoine Augustin Cournot, born in 1801.

Cournot was a french mathematician and economist who in 1838 published *Principes Mathématiques*. Cournot (1897) unveiled the first formal model of oligopoly theory in the early 19th century, yet the earlier importance of Cournot (1897) on economic thought had passed almost unnoticed by his fellow contemporaries both in England and France. However, some thirty years after his death, his book began to be object of interest among English economists through Jevons (1879) second edition preface[1]. Although today Cournot's theory is considered one of the benchmark models of oligopoly in late nineteen century, had received a bad reception amongst his contemporaries[2]. A few of these critics are reported by Shapiro (1989) on Edgeworth's writings, which includes Bertrand critics on Cournot's idea of no production cost, Marshall's on the case on which the cost follows the law of decreasing returns, and also shows that Fisher in his turn thought Cournot (1897) treatment of duopoly brilliant though not absent from serious problems.

Cournot (1897) presents his duopoly model in *chapter VII: of the competition of producers*. Cournot proposes a scenario where two proprietors and two springs with the same qualities (homogeneous goods) supply the same market. Consequently, he argues that prices are necessarily the same to each proprietor. In Morrison (2001, p. 162), conclusions on Cournot's price setting are established. Morrison (2001) recognises "that a proprietor's price is the price posted by that proprietor and may or may not be the market price". There is no production cost in Cournot's duopoly model, so if p is the price, $D = F(p)$ is the total sales, D_1 the sales from spring (1) and D_2 the sales from spring (2), then $D_1 + D_2 = D$. Cournot (1897) goes further in his analysis, talking about proprietors' incomes (pD_1 and pD_2), and how each of them independently seeks to make their income as large as possible.

In today's textbook model, firms substitute the formerly called proprietors, homogeneous goods replace the springs, there is a zero marginal cost, and a linear demand function is taken. This is a one-shot game in which firms react to each others' choice of output. So, we have firm 1 and firm 2 with a $y_1 + y_2 = Y$ produced level of output and price p that would "clear the market". Therefore, consumers are buying insofar there is a production to be purchased, which means that firms are offering their good at such a price that all of their production is sold. For Besanko et al. (2009, p. 222), a price that clears the market is the market price which empowers both firms to sell all their production. Cournot equilibrium is simply the pair of outputs at which the two reaction curves cross. At such a point, each firm is producing a profit-maximizing level

[1] An earlier discussion on Mathematical Economics is mentioned by Marshall (1920, p. 56).

> An excellent bibliography of Mathematical Economics is given by Prof. Fisher as an appendix to Bacon's translation of Cournot's Researches, to which the reader may be refereed for a more detailed account of the earlier mathematical writings on economics...

[2] I rely here on Shapiro (1989, p. 330) for the reference to critiques on Cournot's work.

of output given the output choice of the other firm (VARIAN, 1992).

Cournot (1897) work received its first thoroughly review when another french mathematician named Joseph Bertrand presented his duopoly model in the year 1883. The year was 1822 when Joseph-Louis-François Bertrand was born in Paris and during his lifetime he became a professor at the École Polytechnique, developing works on different scientific fields[3]. While Cournot's model was competition in outputs, Bertrand's oligopoly model was competition in prices. Remember that in Cournot model states that proprietors simultaneously and independently make a decision about how much to supply and just after that they bring those goods to the market. Cournot also notes that market price equates total supply and demand. Now, considering Bertrand's model and his story, as put by Kreps e Scheinkman (2005), that in such model producers are simultaneously and independently naming *prices*. Hence, consumers will allocate their share of income purchasing from the lowest price producer(s) who only *then* produces the demand they encounter. In Bertrand's model, producers know upfront how much is demanded in their market. If the lowest-price producer cannot meet total demand, the amount of supply will be offered by the second lowest price producer and so on until all demand is satisfied by supply. Two differences are easily perceived in these stories. The first difference is that in Cournot's there is an auctioneer determining price, while in Bertrand's occurs price competition. The second difference concerns with the time period in which production takes place. "Bertrand outcome requires both price competition and production after demand determination" (KREPS; SCHEINKMAN, 2005, p. 201). Clearly Cournot quantity model ignores the fact that in practice firms choose prices rather than quantities as their strategic variable (SHAPIRO, 1989). A closer look at Cournot (1897) price formation process shows that it is somewhat rather mysterious. Mainly, Bertrand's critic on Cournot's work was based on the firms strategic variable choice being the output. In Bertrand's model, firms behave reacting to each other's price choice. Varian (1992) characterizes a Bertrand equilibrium as one with no marginal cost, homogeneous goods and firms searching for a pair of prices that each one of these prices are a profit-maximizing choice given the choices made by other firm. Well, it turns out that Bertrand's equilibrium is the same as a competitive equilibrium, where price equals to marginal cost. This is surely a very strange result, because how can there be only two firms in a market and the result equilibrium is the competitive one?[4] One can look at Bertrand's oligopoly model in such fashion as Varian (1992) did. It is looked as a model of competitive bidding.

> "Suppose that one firm "bids" for the consumers' business by quoting a price above marginal cost. Then the other firm can always make a profit by undercutting this price with a lower price. it follow that the only price that each firm cannot rationally expect to be undercut is a price equal to marginal cost" (VARIAN, 1992, p. 495).

Even though by the end of the 19th there were already two oligopoly models with different ways to present strategic variable choices of firms, the next model only appears in 1934. An influential paper by a German economist Heinrich von Stackelberg, whose work on market organization, *Marktform und Gleichgewicht*, set the first leader-follower interaction model. So, in the same way as simple quantity games are attached to Cournot's name and simple pricing

[3] Besides economics, Bertrand, also developed contributions on statistical probability and "elegant applications of differential equations to analytical mechanics, particularly in thermodynamics" (BRITANNICA, 2013)

[4] Bertrand's oligopoly model is further developed in the forth chapter.

games are attached to Bertrand's name, also Stackelberg's is associated with industries description in which there is a dominant firm, or natural leader (VARIAN, 1992, p. 482). Stackelberg leadership demonstrates the value of being the leader, currently defined as *first-mover advantage*. In a Stackelberg model the leader first selects its output and then, the other firm follows with its own output choice (SHAPIRO, 1989). "Formally, the leader's strategy is an output and the follower's strategy is a function specifying its output for each possible output by the leader" (SHAPIRO, 1989, p. 389). In today's terminology Stackelberg and Cournot equilibria are each (subgame perfect) Nash equilibria, but to different games[5]

The development of fruitful theories took a few generations to achieve what is considered the pinnacle of oligopoly theory. Although today's oligopoly theory is mainly focused on game theory itself, it can still be surely located conceptually in-between monopoly theory and pure competition.

Modern game theory was developed by the famous mathematician John von Neumann in the mid-1940s. Von Neumann worked with the economist Oscar Morgenstern and "among other findings they established a general way to represent games mathematically and offered a systematic treatment of games in which the players' interests were diametrically opposed" (VARIAN, 2002). These sorts of games (zero-sum games) are common in sports, however, most of the games that interests economist are non-zero sum[6]. Varian (2002) said that the von Neumann-Morgenstern analysis of non-zero games was not satisfactory as their work on zero-sum games. In order to analyse these two types of games they used different sets of tools. Despite of the not so good von Neumann-Morgenstern analysis for non-zero sum games, soon enough another game theorist titan would emerge with his own new set of tools. Princeton mathematician John Nash[7] in his writing's on game theory came up in 1951 with a much better way to look at non-zero games. Furthermore, his method had the advantage for being equivalent to the von Neumann-Morgenstern method if the game happened to be zero sum. What Nash proposed was to look for outcomes in which each player is making an optimal choice, given the choices the other player are making (VARIAN, 2002). This reasoning happens to be what today we call Nash equilibrium. Nash equilibrium is a pair of strategies if A's choice is optimal, given B's choice, *and* B's choice is optimal given A's choice (VARIAN, 1992). What is very important to remember is that neither parts know about the others choice of strategy. As noted by Dixit e Nalebuff (1993), Nash's idea underlines the rule of behaviour for simultaneous-move

[5] "Without the refinement to subgame perfection, any output by the leader giving him non-negative profits would be an equilibrium (much as any individually rational outcome is a an equilibrium in the simultaneous-move output game if the firms' strategies are supply functions). All but one of these equilibria are supported by incredible threats on the part of the follower, however" (SHAPIRO, 1989, p. 390).

[6] When two individuals voluntarily trade they typically are made better off. See Varian (1992)

[7] John Nash received the Nobel Prize in economics in 1994 for his contributions on game theory.

games. According to Varian (2002) the main problem regarding game theory is the assumption of full rationality[8]. Nowadays, researches at the frontiers of game theory worry about the limitations of the Nash equilibrium concept. "They have developed games where intuitively obvious outcomes are not Nash equilibria and vice versa. But these issues do not affect most applications of game theory" (DIXIT; NALEBUFF, 1993, p. 78).

Monopolistic behaviour is established when a firm is capable of setting simultaneously price and quantity. However, the majority of markets are oligopoly structures, therefore there is a necessity of using a comprehensive economic theory to deal with the analysis of such markets. Furthermore, simple but intuitive models are very important when dealing with business decisions purposes such as how much supply should one offer, or what kind of cost structure should one pursue and finally if there are better methods available that leads to business strategies that would help a firm to overpower competitors .

Although oligopoly theory has a comprehensive literature encompassing static oligopoly theory, repeated oligopoly games, two-stage competition and dynamic rivalry (SHAPIRO, 1989), this work is concerned principally with strategic positioning of firms and their unfolding results.

1.2 Very brief history on software industry

Campbell-Kelly (2003) divides the software industry into three main types of firms, *(i)* software contractors; *(ii)* producers of corporate software products; and *(iii)* markers of mass-market software products. The next two sections deal with both *(i)* software contractors and *(ii)* producers of corporate software products. However, in the interest of the scope of this work, the third type of firm, *(iii)* markers of mass-market software products, is developed in more detail in the next chapter. Dividing the industry of software development into three different types is somewhat important because of the distinctive business models that emerged and evolved trough those products. While Campbell is focusing his historical analysis effort mainly on the United States of America software industry, this thesis concerns mostly with a specific sector of that industry. This work analyses producers of mass-market software developed specific to take place as operating systems for mobile technology devices. The software industry is very diverse and peculiar, contemplating big corporate companies to small startups. Peculiarities are involved with their products either, because sometimes a software is sold in just one copy, sometimes are sold 100, or even 10 million copies (CAMPBELL-KELLY, 2003). This kind of difference is the reason why looking at a specific sector makes sense.

[8] "In real life, most people, even economists, are not fully rational" (VARIAN, 2002)

.

1.2.1 Software contractors

(i) Through the 1950s, *pari passu* with the corporate mainframe computer industry the software contractors developed custom-written programs for both corporate firms and the United States government. These programs were very expensive. Indeed, an invoice near one million dollars associated with those software was a commonplace (CAMPBELL-KELLY, 2003). The example of how custom-written software worked as a business opportunity is the SAGE air defence project alongside with L-Systems. These projects were a US-government multi-billion-dollar defence initiative that began during the 1960s, and, creating an enormous opportunity for the early software contractors. With small startups beginning to arise responding to this demand, firms "such as Computer Usage Company (CUC), System Development Corporation (SDC) and the Computer Sciences Corporation (CSC) came into existence" (CAMPBELL-KELLY, 2003, p. 5). Custom programming business model effectively took shape in the same way as a engineering or construction contractor firm did by participating in biddings for contracts. This business model allowed those companies to evolve from small startups to very successful big corporations that were competing for the largest software contracts. Some crucial capabilities had to be developed by those software contracting firms alike exploitation of scope, cost estimation, and project management (CAMPBELL-KELLY, 2003).

The matter of specialization into a specific segment of the software market is present since the beginning as is seen by taking an historical account. Specialization was developed by companies since System Development Corporation (SDC) specialized in real-time defence projects while Computer Sciences Corporation (CSC) focused on systems software for computer manufacturers. Concentrating on these narrow markets gave the ability to those firms to reuse software from one project to the next, producing a cost reduction which was very welcomed due to low profit associated with custom-written software business model. One drawback of the custom software contractors at strategic level, however, was that they had strong path dependencies related to the founder's experience, also they were highly individual and idiosyncratic with financial constraints and business networks (CAMPBELL-KELLY, 2003).

1.2.2 Corporate software products

(ii) Meanwhile, a new type of business opportunity emerged with the launch of the IBM System/360 computer family: corporate software product with no need of modification that could be used by many user. The IBM computer created a new branch of market for software developers. The ignition of boost in this sector's sales were driven by the relatively inexpensive price of the computer, thus creating a much "broader market for lower-cost software than could ever have been satisfied by software contractors" (CAMPBELL-KELLY, 2003, p. 4). These type of software were developed to automate ordinary business functions, such as payroll or inventory management (CAMPBELL-KELLY, 2003, p. 4). Corporate software products were sold chiefly to business client with prices varying from five thousand to a hundred thousand

dollars. Corporate software products or packed programs such as Applied Data Research's Autoflow and Informatics Mark IV[9] are generally agreed to be among the first and most influential of the early software products (CAMPBELL-KELLY, 2003). In 1970, the giant IBM, under antitrust pressure decided to charge separately for software and other services those which were previously supplied for free. The "unbundling" decision had the effect of establishing a basically new market for software products. Due to that decision made by IBM, a turning point for the whole software industry started to take place.

Informational goods have a very unique feature when production is taking place. Namely, they have a low incremental cost, i.e. low marginal cost of production. Due to this feature, shared by other types of goods, software programs were considered by software products manufacturers very good business to be within. For instance, the early and deathly association with the music industry led software producers to enrol in a business model that had very expensive marketing costs. This decision made by those producers led to a business structure very similar to the capital goods industry. Essential competences that firms in the software products sector developed were exploitation of scale (the most important of them all), corporate marketing, quality assurance, and pre-and post-sale support (CAMPBELL-KELLY, 2003). The business role model those firms applied within their boundaries was similar to IBM corporate philosophy. The high amount of spending associated with the development of generalized software products promoted sales volume. This was an important key factor for the success of companies, and also another consequence of basing their business model on IBM's. Finally, as in all capital goods, pre and post-sale support was needed in order to establish a long-term relationship with the costumer. This produced what economists call a high level of switching costs. Switching costs are not involved whenever consumers are changing to an alternative technology and encounter a bundle of advantages that outweighs the cost of not doing so (CAMPBELL-KELLY, 2003). An example of advantage is the network effect. Normally new technologies that are ruled by strong network effects have a tendency to display long lead times followed by explosive growth (VARIAN; SHAPIRO, 1998). Positive feedback plays an enormous role in new technologies because if more consumers are adopting them, for instance increasing the user installed base, more consumers find it worthwhile to switch from the old technology to the new. Critical mass is what permits the take over of markets by some firms(VARIAN; SHAPIRO, 1998).

[9] Announced in 1965 and 1967, respectively.

2 MASS-MARKET SOFTWARE

The third type of firm, mass-market software, began to take off as a business model in the middle of 1970s, right after the creation and dispersion of the first minor wave of personal computers. When the revolution of personal computer began, it was important for the companies to create a way to distinguish software focused for personal computers from those intended to corporate computers. Mass-market software had the most characteristic form of distribution because it was sold in shrink-wrapped boxes in retail stores or by mail order (CAMPBELL-KELLY, 2003). Prices for mass-market software were kept above one hundred and below five hundred dollars allowing enormous sales volumes for the most successful companies within this specific market. Another aspect of mass-market software playing a big role in the strategic positioning of the companies involved is software-based home entertainment. Videogame consoles and computer games are standard examples of software based home-entertainment. In 1985 the Japanese Nintendo company launched in the US market a videogame console named Nintendo Entertainment System (NES). The game cartridge Super Mario Bross.3 grossed 500 million dollars in 1986 (CAMPBELL-KELLY, 2003).

Some regards must be made on how different is the user experience with the state of the the art for software-based home entertainment in the early 21st century. One must remember that the user interface back in the 1980s was basically in text, while in the 1990s graphical interaction was already emerging. Yet more recently users started to interact with technology by touching the screen while moving objects and so on, commonly coined as — interface revolution. Basically mobile technology devices are used to get consumers entertained and those devices are generally used at households for purposes like browsing the web and playing games. Taking a look at what some analysts define as mobile operating system the reader may understand what kind of features those devices are able to perform:

> "mobile operating system ('mobile OS') is the operating system that operates a Smartphone, tablet, PDA, or other digital mobile devices. Modern mobile operating systems combine the features of a personal computer operating system with touch screen, cellular, Bluetooth, WiFi, GPS mobile navigation, camera, video camera, speech recognition, voice recorder, music player, near field communication, personal digital assistant (PDA) and other features" (LLC, 2013).

In early 21st century, the mobile technology devices' dispersion did not pass unnoticed by the big players in the software industry. This work as, the title hints, concerns with three different software producers. On the one hand, there are Apple and Microsoft, participants in the software business since when the first dispersion wave of the personal computer occurred. These companies evolved and adapted their business model to keep pace with the advance in technology. On the other hand, there is Google, that basically at its beginning was a search engine permitting user to surf the world wide web. Google's business model was and still is very

linked to the increase of their consumer base. The growth of the installed consumers base has the sole objective of maximising their revenue stream from advertisements (GOOGLE, 2012). What appears to be just a taxonomy in order to divide the software industry into three different sectors is indeed very useful both in terms of analysing more clearly which are the distinct business models that firms evolved, and, also software firms competencies, knowledge and ability to change in response to a competing treat in their specialized markets (CAMPBELL-KELLY, 2003). Maintaining dominant positions in their sector is due to their knowledge and competencies, though it made difficult for companies to cross over into either of the other three sectors discussed previously.

The Microsoft Corporation is a mass-market software producer that understood thoroughly which capabilities were necessary to sustain the dominance over an entire sector of the software industry. There are more books telling the history behind Microsoft's logo than on the rest of the whole industry altogether (CAMPBELL-KELLY, 2003). Microsoft is often perceived as a latter-day IBM, completely dominating the software industry. Nevertheless, this is simply not true. IBM, at its peak, in the 1960s, had a tree-fourths of market share of the worldwide computer industry — hardware, software and services. Microsoft has never even had a 10 percent share of the software market. For example, although by 1990 Microsoft was unquestionably the best-known software firm in the world, its sales ($1.18 billion) constituted only 3 percent of the $35 billion worldwide market for software products, and only one-eight of IBM's software sales ($9.95 billion). Even though, by 1995 Microsoft's revenues had grown fivefold, to $6.08 billion, it still had less than 10 percent of the worldwide software market, and its sales were still well below IBM's ($12.9 billion) (CAMPBELL-KELLY, 2003). Yet few people outside of the software industry think of IBM as being in the software business at all.
Not until 1998 did Microsoft's software sales exceeded IBM's. In 1999, Microsoft became the most valuable company in the world by stock-market valuation, but its total revenues ($ 19.7 billion) were dwarfed by IBM's ($84.4 billion). IBM was the third-most-valuable company. (CAMPBELL-KELLY, 2003, p. 232). It is a popular belief that Microsoft is a tough player, behaving in a aggressive and predatory way in order to drive competitors out of the business. Sure this is true, however it tells us only part of the story. Many firms have been driven out of business by strategic errors and plain old market forces (CAMPBELL-KELLY, 2003). The year was 1984 when the first widely reported shakeout of the personal software industry happened. As noted by Campbell-Kelly (2003) one reason for hundreds of firm failures was the explosion in the number of competing productivity applications (spreadsheets, word processor and data base programs). Between 1983 and the summer of 1984, of the nine largest software firms, five were in near bankruptcy. But only one exit was caused by Microsoft. Digital Research was losing sales of operating system to Microsoft and due to revenue loss went out of business. By 1995, the personal computer industry was in a situation very similar to the 1960s computer industry, when technology news reporter named the case as IBM and the seven dwarfs. Microsoft dominated every market in which it performed — operating systems, programming languages,

and productivity applications. The only way competition survived, and in some cases prospered, was by operating in markets in which Microsoft did not participate yet. Here we have to note that during the 1990s there were major acquisitions in the software world leading to obvious concentration of the market. Lotus (producers of the Lotus 1-2-3, which were a big hit in the 1980s) was bought by IBM, Ashton-Tate by Borland, WordPerfect by Novell, and Aldus by Adobe Systems (CAMPBELL-KELLY, 2003). The winner-take-all market certainly was a characteristic of the 1990s concentration. Without a trace of doubt the biggest winner was Microsoft. However, the second-tier companies were also highly successful at monopolizing their markets (CAMPBELL-KELLY, 2003). By comparison with mainframe software industry, in which very successful competing suppliers of comparable scale would hit a 20 percent market share, it was commonsensical for the major personal computer software firms to dominate their individual sectors, with 60-70 percent of the market. The essential characteristic attached to market dominance by software producer was and still is, nowadays, the exploitation of economies of increasing returns. Specialized business press came up with a expression to address to market dominance of this sort — *Microsoft economics*.

A firm's path to dominance over a specific market is not a steady one. Leadership over an entire market is to some extent very difficult to achieve. The specific characteristic involved it the dominance process is that when you consider sequential periods of time: it does not last indefinitely as Varian e Shapiro (1998, p. 11) pointed out "the dynamics of software markets: why does a single company tend to dominate for a time, only to be displaced by a new leader?" Following Varian e Shapiro (1998) questioning on how the dynamics of software markets work. Taking into account the replacing mechanism that promote this change of the leader from time to time. It is useful to remember that leadership is in some cases promoted by a question of getting to the market first. Hence, being the first-mover can be beneficial.

2.1 First-mover advantage

First-mover advantages involve four different mechanisms: (i) learning curve; (ii) reputation and buyer uncertainty; (iii) Buyer switching cost; and (iv) network effects. Before developing further these mechanisms, it is somewhat important for the purpose of this segment of analysis to know more about Apple's early days and the forthcoming that brought Steve Jobs company to the position of most valuable company in history — in terms of market capitalization (FORBES, 2012). Apple's stock prices trajectory are depicted on Appendix A at Figure A.1.

The end of the 1970s brought forth a personal computer that changed the game. The Apple II was launched in April of 1977. Funded in 1976, the small firm that developed this personal computer was of course — Apple Computer (CAMPBELL-KELLY, 2003). Steve Jobs and Steve Wozniak were the computer hobbyists whose vision about technology more than

once completely changed the game in different segments of the mass-market software industry. According to Campbell-Kelly (2003) the very first product sold by Steve Jobs company, the Apple, was a basic computer board intended to market for the kit-building hobbyists, i.e. the Apple was originally a do-it-yourself kit which did not even come with a case (TIME, 2012). In spite of the lack of charisma the, first Apple product was succeeded by an unprecedented leap of imagination and packaging (CAMPBELL-KELLY, 2003, p. 202). Apple II packaging consisted of a keyboard, a CRT display screen, and central processing unit. The Apple went on sale for $666 dollars. Surely Steve Jobs was not the only visionary of this sort and soon imitators from entrepreneurial startups joined the market with their version. Competition came from Tandy, a giant electronic retailer, and Commodore Business Machines, a manufacturer of calculators (CAMPBELL-KELLY, 2003). These three personal computers created a significant sized demand for personal computer software. Software package of this sort "were typically priced between $30 and $100" (CAMPBELL-KELLY, 2003, p. 203). It is important to ascertain ourselves that in parallel with the early 21st century mobile technology devices, the role of personal computer in business was not obvious in the late 1970s. Ordinary tasks such as word processing, technical and financial calculations, data processing and decision supports tasks were all managed by corporate mainframes (CAMPBELL-KELLY, 2003, p. 203). If eversuch tasks were already being handled by computers convincing a board of seniors partners of the necessity for spending valuable money purchasing machines that were seen as toys for nerds was a very good spot to put your finger on. Today in hindsight the reader may be wondering about the author coherence talking about the utility behind such useful tools that not only increased productivity at work but changed also social interaction. One must remember the story covered by newspapers in the dawn of the iPhone. Even after all the buzz caused by advertisement. The so called industry specialists did not consider this mobile device as a threat for the personal computer business model.

Back in 1970, one software package caused a shift in the vision of a personal computer as a business machine — VisiCalc. Campbell-Kelly (2003) affirms that the spreadsheet transformed the working life of middle managers. Shortly after that came all the other productivity applications: word processors, databases and communications software. Software package became very popular, enabling the rise of three major firms in the personal computer software industry — Personal Software (VisiCalc), MicroPro (WordStar word processor), and Ashton-Tate (dBase II database program).

There are two examples of first-mover in systems software. Microsoft and Digital Research were already well established before personal computer became a businesses in itself. Operating systems and programming languages for microcomputers had to be developed from scratch. Bill Gates and Paul Allen developed such programming languages for the computer MITS Altair 8800 naming the language as BASIC. This happened just before the release of the Apple II, thus creating a classic first mover advantage for the incipient Microsoft. BASIC made a success in sales therefore showing a niche where COBOL and FORTRAN industry standards

could diversify (CAMPBELL-KELLY, 2003). Digital Research was focusing their efforts on operating system for microcomputer. Sales were done mainly by mail order. Microsoft and Digital Research happened to be very successful in monopolizing their market. Nevertheless, the turning point for both firm was when Microsoft sealed a contract with IBM to develop the operating system for IBM's new personal computer[1]. The contract with IBM gave birth to MS-DOS (MicroSoft-Disk Operating System). MS-DOS was supplied to IBM on royalty basis (CAMPBELL-KELLY, 2003). Tough commitment leading to long lasting monopolist position and behaviour is in the core of Microsoft strategy as a firm. Computer games, add-on hardware cards and programming languages are few of the products developed by Bill Gates company.

Keeping pace with Apple history. The year was 1984 when Steve Jobs announced the Macintosh. Priced at $2495 dollars this personal computer was relatively affordable (TIME, 2012). Thus, it began a wider dispersion of graphical user interface. Yet in 1985 the board members at Apple fired Steve Jobs. His return as CEO was motivated for two reasons. First Apple was operating at loss. Second, because of Microsoft's Windows 95 bit hit as a operating system. After the return of Steve Jobs, Apple invested heavily in research and development. The investment returned in 1998 in the form of the iMac — best selling personal computer in America (TIME, 2012). The main characteristic of the iMac was its user-friendliness. Apart from its ease to use, Apple's computer was a beautifully designed machine. In 2001 Apple again buzzed the world with their new music player. The iPod got impressive sales figures turning into a mania among the american youth who saw a opportunity of fitting an whole music library in their pockets[2]. Young adults and teenager could easily download music from Napster[3] for free. In the same year, Apple launched a new operating system, Mac OS X, advertised as crash-proof. Like all Apple products design played a big role. The impact on user was caused by its aqua look and feel. Furthermore it was build to be easy to use by consumers switching from Windows-driven PCs. Apple probably foresaw the potential for profiting from the lack of legal music downloads after Napster was shut down for copyright infringement. They conjugate their music player with an online store where consumers cloud easily and legally download music for prices near just one dollar. That created the iTunes software which changed the field entirely. "In the first week, iTunes sold 1 million songs; within a year, it sold more than 50 million" (TIME, 2012). Time (2007) considered the first iPhone as the invention of the year, in 2007. Apple announced their entry in the smart phone competitive business in January of the same year. The phone was finally released to the public in June 29 provoking huge queues outside

[1] How Digital Research came to pass up the opportunity to create the IBM operating system has become one of the most poignant episodes in the folk history of the personal computer (CAMPBELL-KELLY, 2003, p. 204).

[2] Here I paraphrased Steve Jobs who actually said: "You can fit your whole music library in your pocket" (TIME, 2012)

[3] Free music-sharing giant that began in 1999 changing for ever how internet users dealt with intellectual propriety

of Apple stores as well good as reviews, acclaiming the features, design, and just a handful of reviews saw that the iPhone was a platform. The OS X operating system was squished into, it permitting a computer alike performance. In the early days of smart phones, firms did not marketed them as hand-held computers, yet instead advertised them as pretty mobile devices with some fancy features. The iPhone not only changed the way consumers interact with mobile devices it remodelled the business in itself. Apple closed a deal with american mobile phone server providers (carriers) to promote consumer lock-in. With a resealed price of $499 dollars for the simplest version of the iPhone, twelve months later it was offered at $199 dollars as long as the consumer signed a two-year contract with a mobile phone service provider. Consumers can still exchange their Apple phone with this sort of deal.

At the beginning of this section were introduced four different mechanisms involved with first-mover advantages. They are further developed on how they take place on economic theory. *(i) Learning curve* refers to when a firm selling higher volumes of output than its competitors in earlier periods will move farther down the learning curve and achieve lower unit cost than its rivals. "Firms with the greatest cumulative experience can thus profitably underbid rivals for business, further increasing their cumulative volume and enhancing their cost advantage" (BESANKO et al., 2009, p. 61). Because learning takes time, accumulating experience and know-how in a specific market can be crucial to strategic positioning. The benefits of learning involve achievement of lower-cost of production, an increase in the quality of goods, and manifest even in more effective pricing and marketing (BESANKO et al., 2009, p. 61). Also, according to Besanko et al. (2009), it is important to differ between learning effects and other scale effects by measuring them with different variables. An example is utilizing cumulative output for learning economies and output during a given period of time when dealing with economies of scale. Economies of learning are different from economies of scale. Hence, the first concept happens when there are reductions in unit cost promoted by the accumulation of experience over time. While, the second one is the capacity to execute an activity performed on a larger scale, at a particular period of time, give a resulting lower unit cost (BESANKO et al., 2009).

(ii) Reputation and buyer uncertainty: experience goods are those whose quality cannot be assessed before they are purchased and used — a firm reputation for quality can give a significant first-mover advantage. Consumers who have had a positive experience with a firm's brand will be reluctant to switch to competing brands if there is a chance that the competing products will not work. Buyer's uncertainty, coupled with reputational effects can make a firm's brand name a powerful isolating mechanism. Newcomers who wish to gain share from the incumbent will set a lower price so as to offer consumers an attractive benefit-cost proposition. An example of this was IBM during 1970s. In the market for mainframe as pointed out by Besanko et al. (2009, p. 427) it would take at least a 30 percent difference in the price-performance ratio to induce a consumer to choose a competing brand over IBM. Besanko et al. (2009) research suggests that pioneering brands profoundly influence the formation of consumers preferences.

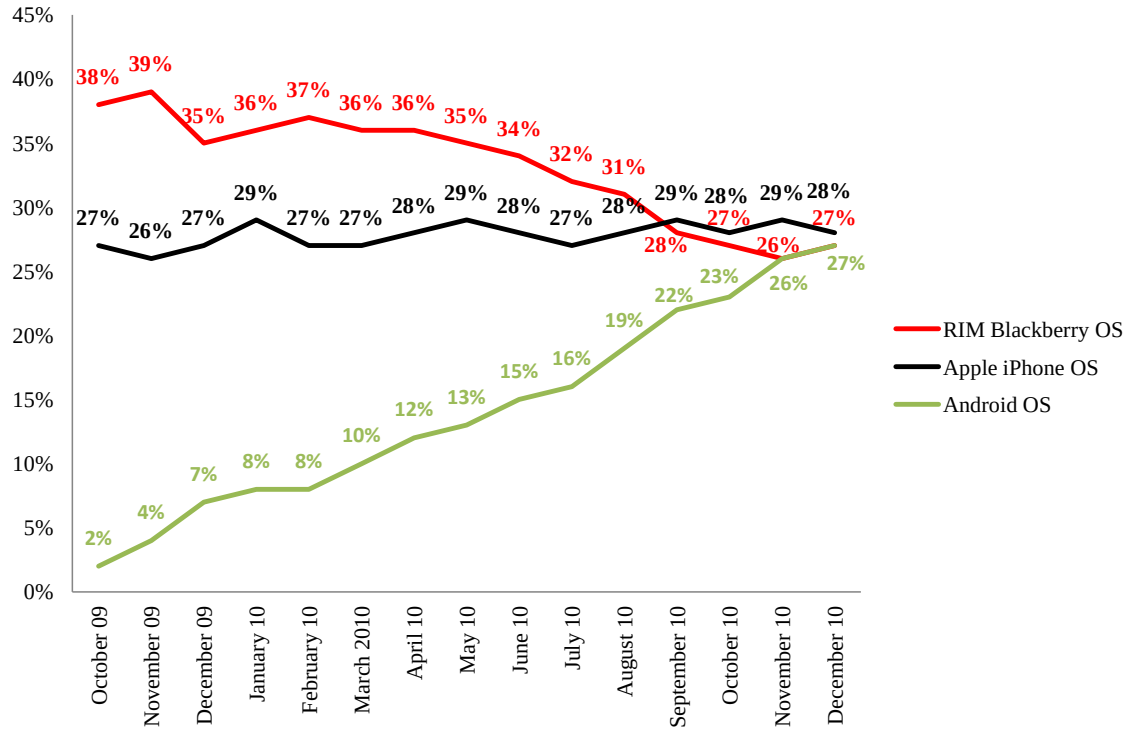


Figure 2.1 – Shows the mobile operating system market share evolution between October of 2009 and December of 2010. Adapted from: (NIELSEN, 2012)

(iii) Buyer switching cost can arise when buyers develop brand-specific know-how that is not fully transferable to substitute brands. Sellers can offer a bundle of complementary goods that fit together in a product line (apple store, apps, ebooks and peripheral products). Switching cost can be a powerful advantage to a first-mover firm. Suppose Apple faces competition form a new entrant, Google, whose operating system provides the same quality as the established firm but requires a cost of S dollars (per unit output) to learn to use. To capture business from Apple, Google must charge a price that is at least S dollars less than the price the established brand charges. Still, the first-mover advantage of switching cost has its limits (BESANKO et al., 2009). Established firms like Apple are less willing to compete on price to gain a more robust consumer installed base. If a established firm such as Apple cuts on prices to attract new consumers, it reduces its profit margin on sales to its existing consumers. To the new entrant, Google, which has no loyal customers, such sacrifice does not incur. The installed base of consumers acts as a soft commitment, inducing Apple to compete less aggressively on price than the entrant does. When this occurs, the entrant (in this case Google) is able to capture a disproportionate share of the market demand growth over time. Figure 2.1 demonstrates how rapidly consumers adopted the operating system developed by Google. Furthermore, Figure 2.1 depicts both the market share loss of Blackberry's operating system as the market share of Apple keeping itself more or less steady during the period described.

(iv) In markets with *network effects*, the first firm that establishes a large installed base of consumers has a decisive advantage. The operating system market has a *virtual network* due to the fact that, as the consumer base in a given network grows, the demand for complementary goods — applications programs, peripheral devices, e-book formats, video games, movies — also increases. This increases the supply of complementary goods, which in turn enhances the value of the network. Network effects raise the essential issue of standards. Many networks externalities depend on standards such as the ones previously reported, yet the standard question brings two key issues. First, should Google, Apple and Microsoft, in this still infant market, attempt to establish a standard, thereby competing for the market? According to Besanko et al. (2009, p. 431), "it is better to be a monopolist half of the time than being a duopolist all the time". As a consequence, *ceteris paribus*, a firm earns higher expected profits by trying to achieve monopoly status for its own standard (competing for the market). When two or more firms compete for the market, the winner is often the firm that establishes the largest installed base of consumers, thereby enhancing the value of the network and attracting even more customers. Competition to grow the installed base can be very costly, however, as firms invest heavily in advertising, pay steep fees to encourage production by complementary product manufactures. For example Apple paid more than 5 billion dollars to app developers. In conclusion, it takes a heavy strategic and financial effort to establish a virtual network, yet it is overall rewarding and has long-lasting effect.

To keep track of who are the leading firms in every segment of the software market is not an easy task. In addition, not all of them may necessarily flirt with a monopolistic approach in their decision-making process. Consequently, the scope of this work chiefly is the segment of the software industry occupied by firm producing operating systems for mobile devices. This analysis concerns with some historical facts, dealing with the reality of three giant firms that a few years ago would have never engaged each other, due to their main software products' applications for end users. Google, Apple and Microsoft product development's history and current strategic manoeuvres on mobile devices niche give us some very different perspectives on the forthcoming consequences for the Personal Computer Era. Generally speaking, giant software makers similar to Microsoft, Google, SAP and many others have a strong tendency to monopolise the market for their main products. However, this is not true for the whole of the industry. As Campbell-Kelly (2003, p. 9) compares the 10 percent of market share that Microsoft holds in the whole industry is correlated with his choice of dedicating something like 10 percent of his book to tell Microsoft's history, since the Redmond company started in 1975. It is widely known that Microsoft is the dominant firm for personal computer software being called to court in an antitrust case back in 2001, *United States v. Microsoft Corpotation*. Journal (2011) describes in short what consequences followed the trial for Microsoft's aggressive strategic choice of behaviour. Department of Justice antitrust regulators obstructed Redmond's company from anti-competitive practices such as those that neglected competing software from developing products on Windows platform. Certainly Netscape Communications Corp. is the

company most remembered to “have faded into obscurity beneath the shadow of Microsoft’s competing Explorer browser” (JOURNAL, 2011).

When looking at how the operating system of Google, Apple and Microsoft compete for the mobile market in today’s business environment, one must remember some theoretical principles concerning economics. Paraphrasing Varian e Shapiro (1998, p. 14), even though technology changes and the business environment in a myriad of ways is different from the beginning of the 20th century, the Economic laws leading to those changes have not. Returning to the days when Netscape browser was Wall Street’s new darling, the business environment was somewhat different in comparison to the early 21st century’s. The largest mass-market software company for personal computer, Microsoft, perceived these changes and manoeuvred tactically to maintain its position.

Netscape business’ model was fundamentally vulnerable for the reason that its main competitor, Explorer, developed by Microsoft, controlled the very operating environment of which a Web browser is only one component. Netscape was facing a interconnection problem because it needed Microsoft’s operating system to work. Interconnection according to Varian e Shapiro (1998) “has arisen over the past century in the telephone, rail road, the airline and computer industries”. Using the case of Netscape browser, acclaimed by the stock market but which failed to meet the expectations about its success, to compare with today’s three different operating systems for the mobile industry technology. It is important to remember that operating systems for mobile technologies, for instance phones and tablets, are one side of the industry. The other side is hardware, which is the infrastructure, while software is the information. Software and hardware are inexorably linked, being examples of complements. Given that neither software nor hardware is of much value without the other, consequently they are only valuable because they work together as a system (VARIAN; SHAPIRO, 1998). The concept of informational goods is a very broad one, since it comprises “anything that can be digitized — encoded as a stream of bits” (VARIAN; SHAPIRO, 1998). Some examples of what informational goods can take form of: books, music, movies, databases, magazines, stock quotes, and Web pages. Because people differ in how they value particular informational goods, there are quite a few different strategies that can be pursued by suppliers of information. Even though information is cheap to reproduce, the creation and assemblage of information is by all means costly. Figure 2.2 illustrates the cost structure of an informational supplier of business package software. Certainly the most interesting revelation, as noted by Campbell-Kelly (2003), was that marketing consumed 35 percent of costs.

Informational goods have low marginal cost yet high fixed costs of production. This cost structure has many implications when asserting price strategy. In the software industry, producing different versions of products play an important role. Considering that consumers associate different utility values with distinct products, price discrimination promotes the absorption of more profit in separated market segments. For example, when Google unveiled the new version of Android, the 4.2.2 Jelly Bean, consumers had to purchase the brand new hard-

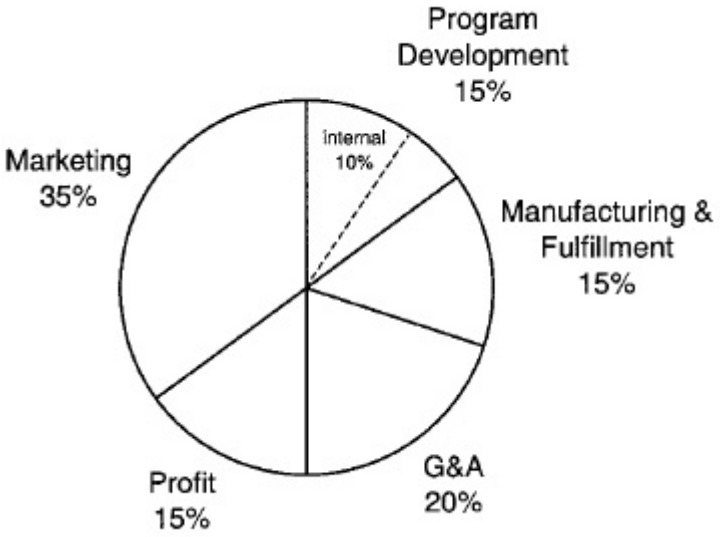


Figure 2.2 – Cost structure of the typical business package "shows the cost breakdown of business and professional personal computer software and was based on data complied by Efrem Sigel of the market research firm Computer Trends Inc" (CAMPBELL-KELLY, 2003, p. 211).

ware, which had embedded the new operating system. Otherwise, they had to wait until the release of the update. Google pricing strategy is to delay the release of the new version for consumers who already have a previous mobile device. This enables a window of opportunity for wishful consumers to acquire the cutting edge of technology. Moreover, depending on which operating system — Android, Windows or iOS —, consumers have it embedded in their mobile device and are directed by the producer either to download a free-of-charge update, or to buy it. Considering Apple iOS 6, either way you must pay for the latest operating system. Given that, you get the latest version buying a brand new iPhone 5, or you can purchase only the software and download it from the internet. Delay is important for firms pricing strategy because it permits extracting more profit from their consumer installed base as well as from newcomers.

Considering Microsoft's strategic alliance with Nokia. Two billion dollars were spent making a contract in which every new Nokia smart phone will have Microsoft operating system. From Windows 8 operating system onwards every Microsoft entertaining device will have the same look. This makes more easy for consumers to adapt and enjoy more (increase the functionality) their mobile devices (smart phones and tablets) as they laptop and desktops. Nokia is well known for their mobile cellphones. Nokia business model has brought them leadership because aimed simultaneously both businessmen (corporate) and teens through building their products with premium materials and colourful and fun materials.

It was June 29, 2007, when the first iPhone went on sale. The most valuable version, with a price tag of $599, had no physical keyboard, limited e-mail options, and no copy-and-paste feature (BUSINESSWEEK, 2012a). Marketed as the new state of the art in mobile phone technology, its marketing campaign caused a big buzz as much on competitors as on consumers. By the middle of 2012, the iPhone reached more than 200 million devices sold around the globe.

The rise of the iPhone clearly caused a new wave of Apple fans and has changed the way of competition on the mobile technology devices. Apple, since 2007, has seen its annual revenue sky-rocketing from 27 billion dollars to 156 billion dollars in 2012, while stock prices soared 400 percent in the same period. Stock prices trajectory and net sales behaviour are depicted at Figure A.1 and Table A.1 respectively. Two aspects on Apple's business model must be cited. First, the major commercial success derives from a "user-centred design"; and second is that the sole creation of the iPhone permitted startup companies like Instagram (2012) go from scratch to 1 billion dollars in just 18 months. This created a new market for applications' development. Apple paid more than 5 billion dollars to app developers. The App Store has 650 thousand application of every sort and purpose. As reported by Businessweek (2012a) Apple's iPhone had the ability to change social culture as it was replacing the old interaction among personal computer user by this new social-media driven behaviour that fit itself in your pocket. Apple marketing skills and appeal are asset that are very difficult to duplicate by competitors.

To see how much the game of competition has changed since the first arrival of the iPhone, consider that in the same quarter, Businessweek (2012a) reports that when "the iPhone was introduced, Nokia and Research In Motion earned a collective 2.7 billion on their handsets". Compare these figures with 2012's net sales for the iPhone and related products, 8 billion, on Table A.1. Table A.1 states that iPhone unit sales reached a staggering total of 125 million during 2012. This represents an increase of 52.8 million units or 73% compared to 2011. "Net sales of iPhone and related products and services were 51% and 43% of the company's total sales for 2012 and 2011, respectively" (APPLE, 2012, p. 31). The iPad tablet and its related products and services also have a representative importance for Apple's strategic behaviour in the mobile devices market, given that net sales of iPad and related products and services were 21% and 19% of the company's total net sales for 2012 and 2011, respectively. Nowadays, Research In Motion is displaying a new set of strategic movement, mainly with the banking sector while Nokia agreed to drop its own operating system development, Symbian, in a 2 billion dollars strategic alliance with Microsoft. "The Finnish company is by far the largest Windows Phone maker; it's responsible for 59 percent of all devices sold with that operating system" (BUSINESSWEEK, 2012b). Windows Phone 8 has received positive feedback from critics, as it is admired by the technology press for its originality and creativity. An important feature of Windows Phone is that of the home screen display being on "live tiles". Due to its originality, Microsoft's phone placed itself away from litigations leading to the U.S. Apple-Samsung trial. Microsoft certainly will be funding massive marketing effort behind Windows Phone 8 in order to increase its consumer base. The main characteristic of Microsoft is its relentless seek for a place in the sun when the the issue is new technologies. Playing tough with precise tactic movements to gain market share has been Microsoft's way to make business since they launched BASIC — a programming language. Technology news reporters and analysts like to look only to the very near future and put their bets against Microsoft's mobile devices. They argue that due to the slow adoption of consumers to Windows Phone 7, the new release (Windows Phone

8), is also doomed to fail. Another skipped thought for news reporters is that, even though they argue that in the U.S market near to half of all Americans possess a smart phone, and therefore opportunities to gain consumers are shrinking, critics lack the ability to look to the worldwide market. Microsoft has been aiming its strategic positioning efforts in the developing world in the same fashion as it had previously done with Windows platform takeover. Developing countries' consumers are rapidly taking notice of the smart phone and tablets revolution on communications (TIMES, 2013). *Pari passu* with the medium income increase in developing countries, consumers are associating a higher level of utility with operating systems embedded in mobile devices that are feasible in their budget. The consumer affordable consumption bundle are those who do not cost any more than their income (VARIAN, 1992)

2.1.1 Regional competition

Economist (2004) article comment on the likelihood of new competitors emerging in the operating system development for mobile devices. According to IDC, a research firm, more than 90% of the 228 million smartphones shipped in the last quarter of 2012 belonged to one of the two dominant operating system - iOS (Apple) and Android (Google). Data shows Android leading the ranks due to the recent growth boom, now reaches 70% world wide. However, in the American market Android operating system reaches 52% while Apple's iOs has 35% as depicted on Figure 2.3.

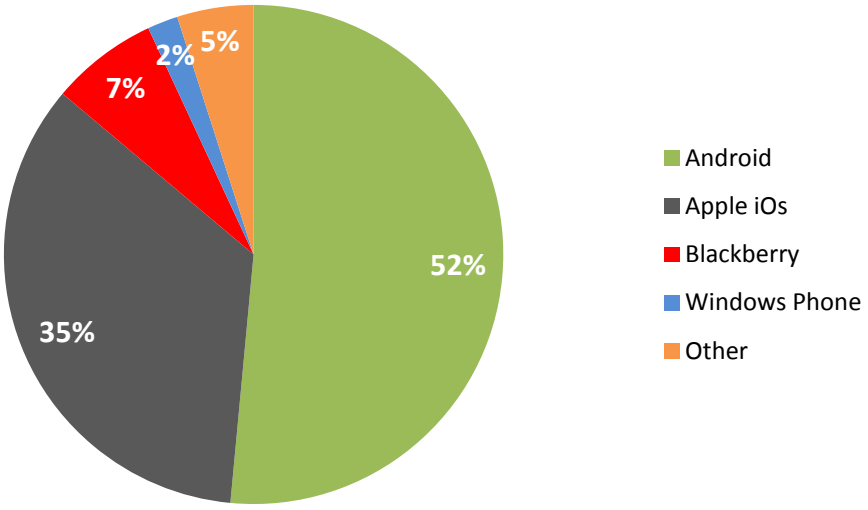


Figure 2.3 – US smartphone operating system by market share, Q3 2012. Generated by the author. Adapted from: (NIELSEN, 2012)

Firefox browser producer Mozilla, a non-profit organization, announced, on February 24, 2013, during the Mobile World Congress, its plans to develop a new smartphone operating

system and bring it to market. Firefox OS already has 18 mobile operators backing the project mainly in Asia and Latin America countries. Mozilla is not engaging alone in this market contest. Few other firms think they can thrive where even a giant like Microsoft struggles to gain market share. Microsoft's Windows 8 platform is the latest trial that Bill Gates' company is making on the phone market. The main difference now is the partnership with Nokia. Filland's firm drop its developing plan of its own OS. However, Nokia's work is not lost entirely because a Finish firm called Sailfish took up the project and develop JOlla. Using the same home screen for personal computers, smartphones and tablets Windows 8 is Microsoft's new attempt to gain the market in the mobile devices. Research In Motion the manufacture of BlackBerry was a major player in the smartphone market is now trying to gain terrain absorbing BlackBerry as the company name and lauching the brand new BlackBerry 10 in January, 2013. Canonical, British company, created Unbutu with an army of volunteers and the help of other firms. Samsung the major adopter of Android is trying to develop a new operating system, named Tizen, their partner is no less than Intel corporation.

Well, but where does all this enthusiasm come from? According to Economist (2004) the main reason for such optimism is unoccupied ground. As Caufield & Byres, a venture-capital firm estimates in 2012 only 17% of the world's mobile subscriptions were through mobile devices. Emerging countries are a huge potential market. In Russia, India and Indonesia the share is less than 10%, while even in rich countries the market is not saturated. Firefox OS is targeting countries like Brazil, Mexico, Poland and Spain. When considering the players like BlackBerry and Microsoft is clear to see theirs advantage due to users familiarity with both system. BlackBerry's users are nearly 80 million people while Microsoft sells the idea of natural knowledge of the personal computer of users. "Microsoft hopes that Windows' dominance of personal computers can be transferred to mobiles" (ECONOMIST, 2004). The biggest obstacle is surely the application for each operating system. Its plain established that users want their familiar app on their mobiles. Thus, solemnly developers of those application will focus their effort producing more applications to the winning operating system. Hence, the installed base increase depends on spending by the firms producing the operating systems to incentive these application developers. Which brings the question of how big are the entry barriers in the oligopolistic mass-market software development for operating system for the mobile technology.

The likelihood of an iPhone consumer exchange brands to a new Windows Phone are scarce due not to the lack of quality of Microsoft's products. This is due to the reason that consumers consider switching costs, brand loyalty and learning experience associated with the purchase of a new smartphone. Businessweek (2012b) states that according to a 2011 survey from UBS, 89 percent of iPhones users intend to buy another iPhone when it comes time to replace their handset. So, consumers balance quality associated with a certain level of utility as depicted in Figure 2.4.

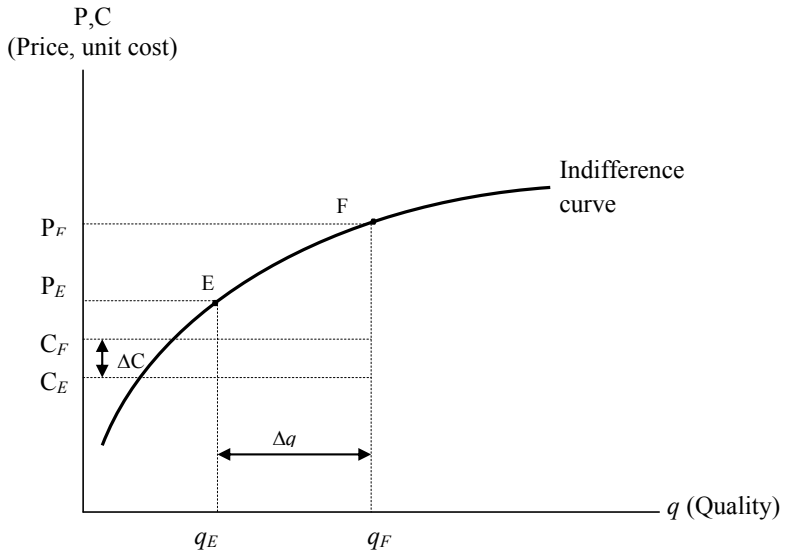


Figure 2.4 – The economic logic of benefit leadership. Generated by the author. Adapted from: (BESANKO et al., 2009, p. 383)

Microsoft's tenacity to gain a niche of market was shown when they first released the Xbox game console. Gaming analysts stated thatit had little change against Sony's very well established PlayStation. Eleven years later, Xbox has near to 47 percent market share and is widely considered to be the dominant gaming platform. Microsoft has mastered what strategy is all about, therefore in the next section, concepts of strategy are discussed in more details.

2.2 Framework for strategy

First of all we have to ascertain what strategy is. Let us consider what some leading contributors defined as strategy.

> "...the determination of the basic long-term goals and objectives of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals'" (CHANDLER, 1962, p. 13).

> "...what determines the framework of a firm's business activities and provides guidelines for coordination activities so that the firm can cope with and influence the changing environment. Strategy articulates the firm's preferred environment and the type of organization it is striving to become" (ITAMI, 1987).

Strategy, as defined above, suggests that it has to do with decision making that last for some period of time. Long-term goals as noted by Chandler (1962) inclines us to assume that once set in motion, those decisions are making a pattern to be followed. Consistent behaviour is the key for a firm's strategical decision making. Finally, the idea that strategy defines what kind of

company “is or should be suggests that strategic decisions shape a firm’s competitive persona, its collective understanding of how it is going to succeed within its competitive environment” (BESANKO et al., 2009, p. 1). Besanko et al. (2009) argues that firms do not randomly achieve success. Moreover, case studies such as *The New Market Leaders* by Fred Wiersema are very difficult to generalize for the whole industry. This is because mimicking strategies in order to seek the same successful pattern of other firms excludes the complexity of strategic decision making and its unfolding results. A “monkey see, monkey do” choice of strategy guarantees no success in any business environment. Hence, the success or failure of a organization is deeply interconnected with its strategy choice. Well, looking at past strategic choices of successful organisations will not assist on generalising a thumb rule for decision making. Therefore, solid economic principles are useful in order to understand what firms do when dealing with strategy.

2.3 The market, substitutes and competitive advantage

Some important questions arise when thinking about an oligopoly industry, though first there must be certainty that the object of scientific analysis, the market in question, is truly an oligopoly. Therefore, from the former argument on different types of markets (perfect competition, monopoly and oligopoly) there was an question left unanswered: how to know which type of industry is being faced? Well, that is easier said than done, as in order to answer this question one has to determine how *interdependence* amongst firms work. So if only the number of firms in one specific market is taken into account, the result will probably be a weak assumption on which type of market is. This happens due to similarities between a perfect competitive market, with many competitors and homogeneous goods; an oligopoly, with many competitors and homogeneous goods; and a monopoly, with many competitors and heterogeneous goods. So there must be a more fundamental characteristic that permits the distinction between perfect competition, monopoly, and oligopoly. There are two fundamental characteristics concerning *interdependence* amongst many firms. On one hand, the influence that one firm has on another’s profitability, when making decisions concerning the amount of goods that should be produced, must be observed: $\partial \pi_i / \partial y_i$. If this mixed partial is inconspicuous, that little effect on profits satisfies the condition for perfect competition as far as monopolistic competition with many firms. On the other hand, if there is a large effect on $\partial p_i / \partial y_j$, the industry is an oligopoly, since price-quantity combinations and profits of a oligopolistic scenario rely on all components constituent of a certain market.

In the of what type of oligopoly structure these companies face and what strategies are they pursuing, it must be defined what market are they into and if their products are substitutes in any degree.In the mobile phone market, after the introduction of iPhone, the issue of perfect substitutability among all mobile phones must be addressed. When considering the three main operational systems available today a simple, however, important concept is that of product substitutes. Given that two products A and B are substitutes when the price of B increases

and the price of A stays unchanged, it is natural to assume that purchases of B go down and purchases of A go up. The cross-price elasticity of demand:

$$\epsilon_{BA} = \frac{\frac{\Delta y_B}{y_B}}{\frac{\Delta p_A}{p_A}} \tag{2.1}$$

measures the degree in which goods substitute for each other. If products are A and B, then the cross-price elasticity measures the percentage change in demand for good B resulted from a one percent change in the price of good A. When ϵ_{AB} is a positive number, it indicates that consumers purchase more of good B as the price of good A increases, therefore goods A and B are substitutes. Nevertheless, there are other ways to identify products that are substitutes. Besanko et al. (2009) enumerates three conditions that tend to hold when identifying close substitutes. The first condition focuses on how similar are the products performance , while the second condition focuses on how similar are their occasions of use, and finally the third condition focuses on the geographic market of the products. The condition of performance alike, first condition, is well established due to the definition of mobile operating system given previously in this chapter (2). The second condition,the occasions of use, as well can be addressed with same definition of mobile operating systems, and finally the geographic market defined in this thesis is the United States of America. Hence, covering all three conditions noted by Besanko et al. (2009) that tend to hold when identifying close or perfect substitutes.

2.4 Why only the perceived high-quality is important

Heal (1976) notes that Gresham's Law, which says that bad products drive out good, may not be valid at all times, due to different contexts. In a dynamic context, the validity occurs only if traders are sufficiently short-sighted, they discount the future benefits at high rates. In Arkelof's problem and the prisoner's dilemma, Heal (1976) considers two traders A and B, each of them are endowed with stocks of commodity a or b, respectively. Those stock are not homogeneous, hence he divided into high-quality a (respectively b) and low-quality a (respectively b). The owner of the stock can perceive correctly the quality of his own stock of commodity, therefore the other trader cannot be certain about the high-quality or low-quality of each others goods.

- Gaining a high-quality b is worth α
- Gaining a low-quality b is worth β
- Losing a high-quality a is worth γ
- Losing a low-quality a is worth δ

Table 2.2 – High-quality or low-quality game strategy

		B's strategy: High *b*	*B*'s strategy: Low *b*
A's strategy	(High *a*	$\gamma + \alpha$	$\beta + \gamma$
		$\gamma + \alpha$	$\alpha + \delta$
	(Low *a*	$\alpha + \delta$	$\beta + \delta$
		$\beta + \gamma$	$\beta + \delta$

Source: (HEAL, 1976, p. 500)

Kranton (2003) reviews previous literature concerning quality as a choice variable for a firm. Kranton affirms that, derived from past literature, the main reason leading firms to produce high quality good is to keep their reputation with consumers. Kranton (2003) focuses on finding that when firms are competing for market share, there is no need for the existence of perfect equilibria, in which these firms produce high quality goods. "Competition for consumers can eliminate the price premium needed to induce firms to maintain a reputation for high-quality production" (KRANTON, 2003, p. 385). The theoretical findings in her paper is different in comparison with the works on quality-assuring prices mainly those of Carl Shapiro, Allen and Klein-Leffler. On previous models by Shapiro and Klein-Leffler, firms would be facing a perfectly elastic demand at the quality-assuring price, while on Allen's model, consumers are choosing randomly among the firms charging the lowest price. Kranton (2003)'s model firm can compete in prices for market share in a fashion that allows firms with lower prices to attract new consumers to the business increasing "current and future clientèle". Although those models consider perfect competition the approach on this work is expanded to how competition concerning quality will look in an oligopolistic market. "The key condition is whether a firm can increase and consolidate its market share by attraction new consumers with a price cut" (KRANTON, 2003, p. 385). The propriety of producing a permanent market share increase using the expansion of the costumer base holds, according to Kranton, a credible promise of producing high-quality goods. Firms are looking ahead into the future and if the profits from selling to a larger costumer base in the future is higher than the short run gain from cheating and producing low quality. When assuming gains from the permanent increase in market share by a larger consumer base on the one hand, while having no sufficiently large permanent increase in market share on the other, firms have the incentive to produce low quality goods in the current period, "taking the advantage of the temporary increase in the number of consumers" (KRANTON, 2003, p. 385). In order to achieve dynamic consistency in the repeated interaction between consumers and firms, Kranton uses the equilibrium concept of sub-game perfection.

> "At any point in time, a firm must produce high-quality goods if the discounted profits from producing high-quality goods exceed the discounted profits from producing low-quality goods"(KRANTON, 2003, p. 385).

The rational consumer benefits from switching firms if firms offer their products with a credible promise of selling high-quality goods at a lower price. The supply of goods must be at a price low enough to induces consumers to switch firms, enlarging the consumer base of that firm. A closer glance at Shapiro's model shows that consumers are not deceived by lower prices because of the assumption of quality assuring price, and below that, consumers will not believe that firms are producing high-quality goods. So, Shapiro shows that an entrant firm has no incentive to charge below the current market price in order to attract new consumers.

> "If a firm can build market share by cutting prices, a consumer-enforced reputation mechanism is not sufficient to sustain high quality. A firm could lower its price in one period, *credibly* offer high-quality goods at a strictly lower price than all other firms, and increase its market share" (KRANTON, 2003, p. 385).

The credibility of a firm's promise to provide high-quality goods depends not only on its current prices but on its anticipated future prices. As a result, when all firm are charging the quality-assuring price and firms are using collusive pricing strategies, an individual firm could gain by cutting its price in one period.

2.5 Strategic commitment and competition

Consider the hypothetical case in which the software industry is an oligopoly. Here is described more specifically the niche of the software industry where firms are makers of mass-market software products. The software being produced is the operational system for mobile phones. Android, iOS and Windows operational systems were developed respectively by Google, Apple and Microsoft. Consider the hypothetical case in which Microsoft, the smaller competitor, is contemplating its production capacity strategy and considers two options: aggressive behaviour and passive behaviour. The aggressive strategy consists of a large and rapid increase in capacity aiming a expansion on Microsoft's market share, while the passive strategy involves no variation in Microsoft's current capacity. The dominant firm, Apple, faces the same two options when contemplating capacity expansion.

Next are presented two *hypothetical* games. The *players* involved in this games are *Microsoft* and *Apple*. Each of the firms has two choices of *strategy* — to deploy an *aggressive* or a *passive* behaviour. The pay-off matrix is depicted at Table 2.3. In this game there is a unique Nash equilibrium if both firms choose their strategy simultaneously. If Apple chooses aggressive and Microsoft chooses to act passively, this would yield a net present value of 15 for Microsoft and 6 for Apple. However, for Microsoft this is not the best outcome. Microsoft is always better off if Apple chooses to behave with a passive strategy. However, without Apple's cooperation, this cannot be achieved. The only way that Microsoft could improve this equilibrium is by committing itself to an aggressive strategy no matter what. So instead of the Nash

Table 2.3 – Simple strategic selection game

		Apple	
		Aggressive	Passive
Microsoft	Aggressive	$12, 4$	$16, 5$
	Passive	$15, 6$	$18, 6$

Generated by the author. Adapted from: (BESANKO et al., 2009)

equilibrium (Passive, Aggressive), there ought to be a new Nash equilibrium, by eliminating the passive strategy for Microsoft. The new Nash equilibrium is now (Aggressive, Passive), which yields a net present value of 16 instead of 15 for Microsoft. This example illustrated at Table 2.4 depicts the fact that "strategic commitment that seemingly limits options can actually make a firm better off" (BESANKO et al., 2009, p. 240). Microsoft's choice of an inflexible strategy was a valuable tool when altering its competitors expectations about how it will compete. Commitment can have two effects on profitability: a direct effect and strategic effect. The strategic effect takes into account the competitive side effects of the commitment. It can be positive or negative, that is, it can benefit or harm the firm making the commitment. While the strategic effect may alter market equilibrium, the direct effect has an impact on the present value of the firm's profits. Here it is assumed that whoever is making the commitment is altering its tactical decisions, while the other firms keep their own tactical manoeuvre.

Table 2.4 – Commitment to Agressive strategy game

		Apple	
		Aggressive	Passive
Microsoft	Aggressive	$12, 4$	$16, 5$

Generated by the author. Adapted from: (BESANKO et al., 2009)

A commitment made by Microsoft to a certain strategy must attend three characteristics in order to produce a correct response from Apple and Google. Besanko et al. (2009) states that a commitment must be visible, understandable and credible. "A competitive move does not represent a true commitment unless it is difficult to stop once it is set in motion"[4]. Irreversibility adds credibility to Microsoft's strategy choices. Public announcements with plans to expand capacity could be seen as cheap talk, whereas contracts, expenditures on research and development, creation of relationship-specific assets are have high commitment value.

[4](BESANKO et al., 2009, p. 241)

2.6 Strategic complements and strategic substitutes

While strategic complements and strategic substitutes are capturing how competitors react when changes on price or quantity occur, tough and soft commitments demonstrate whether a commitment a given firm make places its rivals at a disadvantage. Determining whether actions are strategic complements or substitutes involves careful consideration of the competitive interdependence among firms. Normally prices are strategic substitute and quantities are strategic complements as depicted at Figure 2.5.

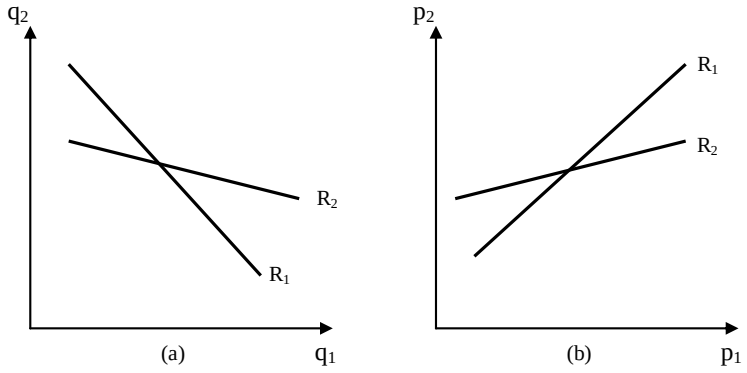


Figure 2.5 – Strategic substitutes and complements — shows both reaction curves for a Cournot industry on the left panel (a), as for a Bertrand industry, on the right one (b). Adapted from: Besanko et al. (2009).

Varian (1992) developed in his work a way to understand where the concepts of strategic substitutes and complements has arisen. Varian (1992) work is presented as follow: given that firm 1's maximization problem is:

$$\max_{y_1} \pi_1(y_1, y_2) = p(y_1 + y_2)y_1 - c_1(y_1). \tag{2.2}$$

A Nash-Cournot equilibrium must satisfy the two first-order conditions:

$$\begin{aligned} \frac{\partial \pi_1(y_1, y_2)}{\partial y_1} &= p(y_1 + y_2) + p'(y_1 + y_2)y_1 - c_1'(y_1) = 0, \\ \frac{\partial \pi_2(y_1, y_2)}{\partial y_2} &= p(y_1 + y_2) + p'(y_1 + y_2)y_1 - c_2'(y_2) = 0. \end{aligned} \tag{2.3}$$

While the second-order conditions are:

$$\frac{\partial^2 \pi_i}{\partial y_i^2} = 2p'(Y)y_i - c''(y_i) \leqslant 0 \quad \text{for} \quad i = 1, 2; \quad \text{where} \quad Y = y_1 + y_2. \tag{2.4}$$

The reaction curve is a relationship between the firm 1's optimal choice of output in response of its beliefs about firm 2's output choice. This is what the first-order condition determines. If the reaction curve of firm 1, $f_1(y2)$, is defined implicitly by the identity:

$$\frac{\partial \pi_1(f_1(y_2), y_2)}{\partial y_1} \equiv 0, \tag{2.5}$$

$$f_1'(y_2) = -\frac{\dfrac{\partial^2 \pi_1}{\partial y_1 \partial y_2}}{\dfrac{\partial^2 \pi_1}{\partial y_1^2}}, \tag{2.6}$$

the use of differentiation when solving $f_1'(y_2)$ is an attempt to determine optimal changes that firm 1 is making in its output taking firm 2's reaction curve (VARIAN, 1992, p. 286). Equation 2.6 shows that the denominator is negative. It also demonstrates that the slope of the reaction curve is determined by the sign of the mixed partial (VARIAN, 1992, p. 286):

$$\frac{\partial^2 \pi_1}{\partial y_1 \partial y_2} = p'(Y) + p''(Y) y_1. \tag{2.7}$$

Normally, when reaction curves are in the shape of a upward slope, firms' best behaviour are strategic complements. However, when reaction curves are in form of a downward slope, firms' optimal behaviour are strategic substitutes. Considering a Bertrand model, prices are strategic complements because when one firm reduces its prices, the other firm finds more profitable to reduce prices as well (BESANKO et al., 2009). Cournot's model shows the interaction between firms when strategic commitment is substitute, as when one firm increases its quantity, the other firm finds it profitable to also increase quantity. Thus, in a Cournot industry firms are maximizing their profit given its beliefs about the other firm's choice of output, the strategic behaviour is called *strategic substitutes*. Reaction curves for a Cournot industry are downward slopping while the reaction curves for a Bertrand industry are upward slopping[5]. When thinking about quantities in a Cournot industry, they are strategic substitutes since when one firm finds it profitable to increase its production, the other firm finds it too. Prices are strategic complements in a Bertrand industry because when one firm finds it profitable to increase prices the other firm will also arise its own. These concepts describe how firms expect the others to react to its tactical manoeuvres. Aggressive behaviour usually leads to a more aggressive response from competitors.

When firms make a certain commitment, it affects the market equilibrium, thus it is helpful to distinguish between tough and soft commitment. For instance, still on Cournot's competitive model, if Apple intends to make a tough commitment, it could build a new production line (iPhone development), hence expanding its current capacity. In contrast, shutting down a production facility would represent a soft commitment (these actions must be irreversible, as previously mentioned). Considering, now, Bertrand's competition model: if Apple makes a decision to reduce prices, such move is considered an example of a tough commitment, whereas a commitment to increase prices is a soft commitment. Apple's decision to produce a mobile phone was a tough commitment because it led to an increase on its production capacity. Also, Apple's decision to enter the operating system market can be represented as a two-stage game,

[5] See Equation 2.6 for a more precise way to determine whether reaction curve have a upward or downward slope

the first being a stage decision to make a strategic commitment — Apple decides whether or not to commit itself to enter into the mobile phone industry —, followed by a second stage, in which competition (Google and Microsoft) manoeuvred tactically. If competition is a Cournot model and Apple is firm 1, one must anticipate how the commitment will alter the Cournot equilibrium.

2.7 Tough and soft commitment in Cournot and Bertrand equilibria

Consider another *hypothetical* case in which Apple and Google are competing on quantities, for instance, in a Cournot competition. Moreover, only Google is deciding about capacity expansion, while Apple is keeping production capacity constant. Contemplate Apple's iOS as the dominant operational system on the market and hardware production assembled by Foxconn at full capacity. If Google's executives wish to further expand Android's market share, its CEO, Larry Page, makes a public announcement, declaring that the company will expand its production capacity with its assembly partner. Basically, this is a sign that the company gives to consumers. A larger supply of mobile devices embedded with a new version of Android can increase sales volume due to the hypothesis of consumer's choice considering only the perceived quality. If the new operational system is perceived as an innovation, there are two effects: *(i)* supply side and *(ii)* demand side. The supply side effect, considering an innovation, involves reducing the marginal cost of the whole production. Meanwhile, the demand side effect concerns with more interest shown by the public, directed to the new operating system. During the announcement, Larry Page states that the company is engaging in a new partnership with Samsung. If Google does not meet the expectations, the announcement can hurt Page's reputation as a CEO. Therefore, it is reasonable to state that Google is making a tough commitment when announcing expansion of production capacity.

Next at Table 2.5 is presented the *hypothetical* one-shot game. The *players* involved in this games are *Apple* and *Google*. Each of the firms has two choices of *strategy* concerning their production capacity — to *expand capacity* or *do not expand*. The pay-off matrix is depicted at Table 2.5.

Table 2.5 – Expansion of capacity game

		Google	
		Do not expand	Expand
Apple	Do not expand	$18, 18$	$15, 20$
	Expand	$20, 15$	$16, 16$

Generated by the author. Adapted from: (BESANKO et al., 2009)

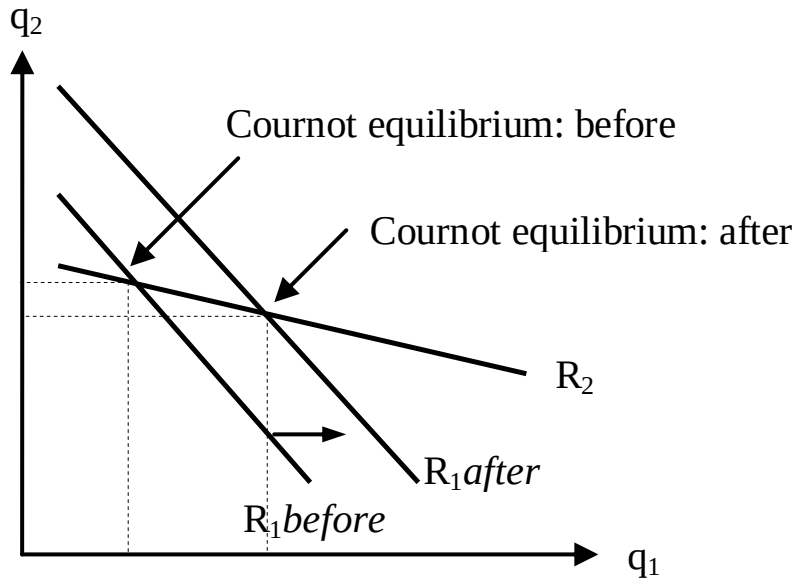


Figure 2.6 – Google's tough commitment in a Cournot market — the beneficial competitive effect of Google's tough commitment can be seen at Figure 2.6 R_1 right shift that results in a Cournot equilibrium where Apple produces less output. Adapted from: (BESANKO et al., 2009).

The result of this *hypothetical* Cournot one-shot game between Google and Apple is that Google's production expansion announcement leads to an increase in production no matter what Apple does. The reaction curve R_1 left shift from R_1^{before} R_1^{after} depicted at Figure 2.6 demonstrates the new Cournot equilibrium achieved when Google expands its production capacity.

3 COMPARING COURNOT, BERTRAND AND STACKELBERG MODELS

A century and a half has passed after the first publication of Cournot (1897),yet, perhaps just in recent years his work achieved full recognition for contributions to economic theory. Some authors even mentioned that they consider Cournot the father of game theory. Morrison (2001) states that, after what he thinks was a long lasting bedazzlement with John Nash, game theory finally recovered from it, and nowadays acknowledges its origins in Cournot's *Recherches*(1838). Quantity choice as a strategic variable is rather important for the understanding of Cournot's model. Recent years brought up academic discussion amongst scholars whether only price rivalry was considered by Cournot, instead of the text books' models, which consider quantity rivalry as the traditional treatment of oligopoly (BORNIER, apud MORRISON, 2001, p. 164). These scholars, raising such questions, affirm that quantity competition is a result from a superficial reading of the *Recherches* (MORRISON, 2001). In truth, Cournot's mathematics do not support Magnan de Bornier's thesis, criticising the quantity rivalry as a strategic choice. Because the model displayed in chapter VII of the Researches, where strategic variables are being chosen by firms, clearly establishes the traditional treatment of oligopoly. Cournot, according to Morrison (2001) introduces price derivatives, using the inverse derivative rule, yet this is done for no other reason than to show that price is really the strategic variable (choice). Another reason for Cournot's way to present his work is with the purpose of changing to price derivatives in an attempt to demonstrate his conjecture. That is, increasing the number of firms in an oligopolistic market will lower price and thus move things in the direction of competition.

> "As Novshek (apud SHAPIRO, 1989, p. 336) points out, simply adding more firms cannot give the traditional Marshallian outcome: with fixed demand, as *n* grows, each firm's Cournot output must approach *zero*, whereas with a U-shaped average cost curve, the competitive limit calls for strictly positive production levels at each firm. Instead, Novshek (apud SHAPIRO, 1989, p. 336) takes the limit of free-entry, Cournot equilibria, as the minimum efficient scale of operation becomes small in comparison with demand. With this limiting procedure, he establishes both that Cournot equilibria with free entry exist as $n \mapsto \infty$ and that they approach perfect competition in the limit."

Cournot's model is presented next following a modern approach as given by Shapiro (1989, p. 333). In the current work are presented both the oligopoly and duopoly models. The first is demonstrated in a more general case, where there is n firms competing to supply a homogeneous good, whilst the demand for which is given by $p(Y)$, where p is the price and $Y \equiv y_1 + \ldots + y_n$ is industry output, y_i being firm$i$'s output. Trough the length of this thesis firm i cost function is represented by $C_i(y_i)$ while marginal cost is represent by c_i'. Profit maximization behaviour is depicted next in Equation 3.1 that represents firm i's profits:

$$\max \pi_i = p(Y)y_i - C_i(y_i), \tag{3.1}$$

if the firm produces y_i amount of goods, also, the total output is Y (SHAPIRO, 1989). This model represents a one-shot game, which means it is timeless. An aggressive firm behaviour is captured by this unique attempt, in order to capture consumers to their customer base. Firms $i = 1, \ldots, n$ simultaneously choose their output, which means that "Cournot equilibrium is a Nash equilibrium in quantities" (SHAPIRO, 1989, p. 334). Equilibrium in a Cournot model is a set of self-enforced actions taken because there are more firms contemplated, competing at the current market (SHAPIRO, 1989). Market is cleared when $p = p(Y)$, given a set of choices (y_i). The Cournot equilibrium output vector, $(y_1, \ldots, Y_n)$, is determined by the n equations, $\partial\pi_i/\partial y_i = 0$, $i = 1, \ldots, n$. Keeping pace with Shapiro (1989, p. 334) description for Cournot oligopoly model, the ith equation is typically called firm i's *reaction curve*, since it represents the firm i's optimal choice of y_i as a function of its rivals' choices. For homogeneous goods, firm i's optimal quantity depends only on its rival's aggregate output, $Y_i \equiv Y - y_i$. The first order condition, $p(Y) + x_1 p'(Y) = c_i$, is given by maximizing π in relation of y_i. Rearranging to $p(Y) - c_i = -y_i p'(Y)$, or

$$\frac{p(Y) - c_i}{p(Y)} = \frac{s_i}{\epsilon}, \quad i = 1, \ldots, n. \tag{3.2}$$

Equation 3.2 is the pricing formula for a Cournot oligopoly. Shapiro (1989) comments that by summing Equation 3.2 across firms one obtains an equation associating the equilibrium price to the sum of the firms' marginal costs, also that Cournot (1897) was aware of this aggregation property.

In Equation 3.2, where $s_i \equiv y_i/Y$ is firm i's market share, and $\epsilon > 0$ is the market elasticity of demand at Y, $\epsilon \equiv -p(Y)/Yp'(Y)$. Even when considering differentiated goods, the existence of a Cournot equilibrium is very general. Shapiro (1989) affirms basically that in order to achieve equilibrium, each firm's profits need to be quasi-concave in its output. Another condition that suffices the existence of an equilibrium is that π_i actually be concave in x_i, in other words $\partial^2\pi_i/\partial y_i^2 < 0$ at all y_i, Y. This is of course firm i's second-order condition. Considering the case of homogeneous products, there is a second order conditions as follows:

$$a_i \equiv 2p'(Y) + y_i p''(Y) - C_i''(Y) < 0, \quad i = 1, \ldots, n \tag{3.3}$$

Shapiro (1989) shows that Equation 3.3 is satisfied if demand function has a concave shape, $p''(Y) < 0$, an also if the cost function exhibits nondecreasing marginal cost, $C'' \geq 0$. However, it can be observed n being exogenous here in order to avoid issues with entry and exit of firms in this particular market. A weaker condition for the existence of equilibrium considering homogeneous would need both demand and cost functions differentiable and monotonic, so long as

$$p'(Y) + Yp''(Y) \leq 0 \tag{3.4}$$

at all Y (SHAPIRO, 1989, p. 335). This condition provided is almost equivalent to:

$$b_i \equiv \partial^2\pi_i/\partial x_i \partial x_j = p'(Y) + Yp''(Y) \leq 0. \tag{3.5}$$

What is being told by Equation 3.5 in short is that firm i's marginal revenue must not rise *pari passu* competition output.

Comparing Equation 3.3 and Equation 3.5 reveals that Novshek (apud SHAPIRO, 1989) generalizations diminishes the requirements on the cost function that are needed to ensure existence. Shapiro (1989, p. 335) review about uniqueness of equilibrium stating that general conditions regarding how many times reaction curves intersect may reduce assurance in relation to uniqueness. For static comparison is very useful looking at:

$$|a_i| > (n-1)|b_i|, \quad i = 1, \ldots, n. \tag{3.6}$$

Equation 3.6 is far too strong condition and must be violated every time when $(a)p$" ≤ 0 and $n \geq 3$, or inequality (Equation 3.5) holds and $n \leq 4$. Having seen these conditions about the existence and uniqueness of equilibrium in the Cournot oligopoly, the next step is to observe how firms perceive their market power, what are the differences between the solutions for competitive equilibrium - oligopoly and monopoly. Also, consequences for elasticity of demand in a symmetric case are analysed, i.e firms that have the same cost function.

Equation 3.2 is the pricing formula for the Cournot model capturing some characteristics of oligopoly behaviour (SHAPIRO, 1989). First, firms can only exert limited market power, due to difference between its price and marginal revenue: $MR_i = p(Y) + x_i p'(X)$, rearranging, there is $p - MR_i = -x_i p'(Y) > 0$. Second, as already seen in an early section, the Cournot equilibrium is in-between the competitive scenario and the monopolistic one. Third, "the greater is the market elasticity of demand, the smaller are the mark ups at each firm" (SHAPIRO, 1989, p. 335). Fourth, the mark up at firm i is directly proportional to the firm's market share. Fifth, market shares of the firms are directly related to their efficiencies. Hence, less efficient firms are able to survive in the industry with positive market shares. Remember Equation 3.2 which is considered the symmetric case, consisting that if the cost function is alike for all firms, we get:

$$\frac{p-c}{p} = \frac{1}{n\epsilon}, \tag{3.7}$$

c is the common level of marginal cost. Equation 3.7 is a monopoly mark up case if $n = 1$. Also, this gives us the notions that a firm competing in an environment that places firms of similar sizes is more competitive.

Cournot's model states that firms are seeking profit maximisation on their own, i.e. independently and simultaneously, given the competitor's choice of output. Taking this into account it is arguable that total industry output is not being maximized. Hence, Cournot's equilibrium from the firms' points of view is not Pareto optimal[1]

[1] Vilfredo Federico Damaso Pareto italian economist. His contributions to economic theory mainly helped the development of Walras' *General Equilibrium Theory* provoking a deep methodological change in Neoclassical economics. Also, Pareto's work in economics led to the creation of a touchstone for valuation of welfare, Pareto optimal (GARCIA, 1996, p. 7).

In a oligopoly market where *product differentiation* exists, quantity setting for producers depends on price decisions made by competitors: $y_i = f_i(p_1, p_2, \ldots, p+n)$, where $i = 1, \ldots, n$. Deriving y_i in relation to p_i, i.e. $\partial y_i/\partial p_i < 0$ and also deriving y_i in relation to p_j, i.e. $\partial y_i/\partial p_j > 0$, for every $i \neq j$. A partial reduction of production level is achieved if the ith firm price grows *ceteris paribus* (that is, all other firm prices stay the same). The firm that set its price higher loses some consumers due to its pricing strategy. However, firms that stay with current price setting gain these consumers. Another way to gain consumer is to produce more goods when a given competitor maintains the same level of production, thus price decreases as the level of production increases at firm level. Considering this oligopoly market with product differentiation, firms' profits also rely on their spending with advertisement. Publicity, when efficiently employed, provokes an increase in the installed consumer base if it allows the firm to sell more quantity with a given price, or at a higher price given certain quantity (HENDERSON; QUANDT, 1976, p. 226).

3.1 Duopoly Cournot model

We have two firms competing in a certain market. We shall call these firms for now firm 1 and firm 2, they produce an identical product. So, let the inverse demand function be:

$$p = F(y_1 + y_2), \tag{3.8}$$

where y_1 and y_2 are the duopoly production levels. Firm 1's total revenue depends on the production level of firm 2 and on its own, therefore there is.

$$\begin{aligned} R_1 &= y_1 F(y_1 + y_2) = R_1(y_1 + y_2) \\ R_2 &= y_2 F(y_1 + y_2) = R_2(y_1 + y_2) \end{aligned} \tag{3.9}$$

In order to find firms profit, the only required measure is to take the difference between total revenue and cost, (HENDERSON; QUANDT, 1976):

$$\begin{aligned} \pi_1 &= R_1(y_1 + y_2) - C_1(y_1) \\ \pi_2 &= R_2(y_1 + y_2) - C_2(y_2) \end{aligned} \tag{3.10}$$

The behavioural assumption is that both firms seek profit maximisation independently. Consequently, the first order condition states that marginal revenues are equal to marginal costs.

$$\begin{aligned} \frac{\partial \pi_1}{\partial y_1} &= \frac{\partial R_1}{\partial y_1} - \frac{dC_1}{dq_1} = 0 \qquad \frac{\partial R_1}{\partial y_1} = \frac{dC_1}{dq_1} \\ \frac{\partial \pi_2}{\partial y_2} &= \frac{\partial R_2}{\partial y_2} - \frac{dC_2}{dq_2} = 0 \qquad \frac{\partial R_2}{\partial y_2} = \frac{dC_2}{dq_2} \end{aligned} \tag{3.11}$$

Even though the first order condition equates marginal revenue to marginal cost, it does not require a condition that duopolists marginal revenues must be the same. Duopolist with a larger

production level certainly have a smaller marginal revenue. Any increase in production made unilaterally results in a decrease in price level therefore affecting both firm total revenue (HENDERSON; QUANDT, 1976, p. 219). Duopolist second order condition require the following:

$$\frac{\partial^2 \pi_i}{\partial y_i^2} = \frac{\partial^2 R_i}{\partial q_i^2} - \frac{d^2 c_i}{dq_i^2} < 0 \quad i = 1, 2, \tag{3.12}$$

therefore marginal revenue for each duopolist must grow less quickly than marginal cost, i.e. $\partial^2 R_i / \partial q_i^2 < d^2 c_i / dq_i^2$ for $i = 1, 2$. The Cournot duopolist market achieves equilibrium if the values of y_1 and y_2 are such that each duopolist maximizes profit, given that both firms level of production do not alter. If $\partial^2 R_i / \partial q_i^2 < d^2 c_i / dq_i^2$ is satisfied one can obtain the equilibrium solution resolving Equation 3.12 for y_1 and y_2.

3.1.1 What does a Cournot equilibrium maximize?

The title is a quote from Shapiro (1989) and to answer such inquiry, one must follow his same procedures. Shapiro (1989) argues that neither industry total profit (Cournot equilibrium does not replicate collusion) nor social welfare (prices are not equal to marginal costs, showing inefficiencies on given resources allocation). As noted by Bergstrom and Varian (1985a) the Cournot equilibrium maximizes a *mixture* of social welfare and profits.[2]

3.2 Bertrand model

Joseph Bertrand in 1883 analysed a different type of competition in comparison with Cournot's model. Indeed, Bertrand criticized Cournot's theory from a perspective of choosing the wrong strategic variable, quantity, instead of price. Shapiro (1989), Varian (1992) both demonstrate that in a Bertrand equilibrium, firms tend to undercut each others' price offer with the sole objective of gaining the entire market, somewhat as the winner-takes-it-all strategy. Part of the problem with a one-shot Bertrand game is that firms choose their prices and then the game ends; it is clear that this is not a standard practice in real-life markets (VARIAN, 1992).At Cournot (1897), as formely noticed, firms select a certain quantity to produce and the resulting output determines the market price. Meanwhile, at Bertrand's model, firms are selecting prices and then stand ready to meet all the demand for its product at that price (BESANKO et al., 2009). Firm 1 behaves in order to maximize its own profits, given a certain price that it believes firm 2 firm will select. Let firm 1 and 2 have constant marginal cost c_1 and c_2 consider, also, that both firms face a market demand $D_{(p)}$. Assume, as Varian (1992) did, that $c_2 > c_1$ both firms produce homogeneous goods, just as in the Cournot's model, therefore the demand curve

[2] See Shapiro (1989, p. 337) for a quick detour and Bergstrom and Varian (1985a) deeper look on the subject.

firm 1 faces is given by:

$$d_{1(p_1,p_2)} = \begin{cases} D_{(p_1)} & \text{if} \quad p_1 < p_2, \\ \dfrac{D_{(p_1)}}{2} & \text{if} \quad p_1 = p_2, \\ 0 & \text{if} \quad p_1 > p_2. \end{cases}$$

A Nash equilibrium in this game is for firm 1 to set $p_1 = c_2$ and to produce $D(c_2)$ units of output, while firm 2 sets $p_2 \geq c_2$ and produces zero. The only Nash equilibrium in prices, i.e. Bertrand equilibrium, occurs if both firms' prices equal to marginal cost, considering of course that firms have the same efficiency, produce homogeneous goods and encounter constant marginal costs (SHAPIRO, 1989). No other price pattern is a Nash equilibrium, by reason that if any firm is choosing a price slightly higher than competitors, it earns no sales. Equilibrium is achieved, also, if both firms match prices, in consequence of the other firm lower its price and take the whole market, rather than half if both equal prices to marginal cost.

There is an equilibrium in a case where firms are facing different marginal costs, so long as the assumption of constant returns to scale is retained (SHAPIRO, 1989). This particular case with n firms, firm i has constant marginal cost, c, and there is $c_1 < c_2 \leq \ldots \leq c_n$. Firm 1 takes the entire market, providing that $p = c_2$ and c_2 does not surpass the monopoly price for a firm with unit cost c_1. In this particular Bertrand equilibrium, firm 1 dominates because it is the most efficient producer, being partially disciplined by the presence of firm 2. Similar to Cournot model and lacing similarity with simpler Bertrand model, here equilibrium is not the first-best allocation, since prices, faced by consumers are in excess of marginal cost. Most oligopoly markets have significant production scale economies involved. Also, considering that the main problem with Bertrand's equilibrium is that it fails to exist absent the special case, where it is assumed a constant marginal cost taking into account homogeneous goods (or close but not perfect substitutes).
With increasing returns to scale, prices are driven down to marginal costs due to destructive competition, hence this is not an equilibrium because prices do not cover average costs. Bertrand's model real drawback to the application of it is the reliance on mixed strategies. Typically, there is an equilibrium in mixed strategies, each consisting on the firm assuming a probability distribution over the prices that the other firm might charge, choosing its own probability distribution so as to maximize expected profits (VARIAN, 1992, p. 292). When interpreting a repeated game, in a Bertrand model with mixed strategies as a model of sales, one ought to have different firms winning at different periods of time. Shapiro (1989) states that small fixed costs added to the basic Bertrand model (constant marginal cost) causes non-existence of equilibrium.

Supposing that neither of the duopolists has sufficient capacity to serve the entire market if price is at marginal cost, but each cannot accommodate more than half of the market at that price (SHAPIRO, 1989). Nevertheless, due to capacity constraints, it also cannot be an equilibrium for each firms set their prices at the marginal cost. Bertrand's equilibrium in the presence of diminishing scale returns of production does not exist. Edgeworth provided a proof

for this in his 1925 work entitled *The pure theory of monopoly*. Given that firms have capacity constrains and are also operating with the same marginal costs, therefore if, for instance, in Apple and Google's case for the mobile software technology, they cannot supply for whole market at the current price. In this circumstances there is no equilibrium because even if Google sells its mobile devices for a lower price than Apple's iPhone. Edgeworth establishes that in this situation, the market cannot meet equilibrium due to incentives to both Google and Apple to undercut each others' prices, going towards a cycle of price cuts. Price war with this characteristics is known as Edgeworth cycle.

3.3 Stackelberg model

In essence, the Stackelberg model is a two-stage model, i.e a sequential game, consisting of a firm moving first, choosing its output level, and only *then* a second firm taking action in response, choosing its own optimal level of output (VARIAN, 1992). Remember the first order condition described in the Cournot section, $p(Y) + p'(Y)y_2 = c_2'(y_2)$, we can derived from it the reaction function of firm i.

Henderson e Quandt (1976, p. 223) says that typically the duopolists profits are a production level function of both firms, so:

$$\pi_1 = h_1(y_1, y_2) \quad \pi_2 = h_2(y_1, y_2) \tag{3.13}$$

A Cournot's solution is obtained, by maximizing π_1 in relation to y_1, i.e. $\partial\pi_1/\partial y_1$, and π_2 relative to y_2, i.e $\partial\pi_2/\partial y_2$. Similarly there is a collusion solution by maximizing $\pi_1 + \pi_2$ in relation to both y_1 and y_2. Duopolists, whose profits functions follow the pattern given in Equation 3.13 may have many other solutions. Another result that can be derived from Equation 3.13 is a leader follower problem. It was first time modelled by a German economist Heinrich von Stackelberg in a paper published in 1934 *Marktform und Gleichgewicht* (market structure and equilibrium). In Stackelber's model, the firm that follows the leader behaves based in a reaction function as $y_1 = \psi(y_2)$ and adjust its level of production in order to maximize its profits, considering production level taken by the industry leader (HENDERSON; QUANDT, 1976). The industry leader, by its turn assumes a behaviour compliant to its belief that the follower behaves according to the reaction function described above. As a consequence, the leader believes that the follower takes into account its choice, and then the leader maximizes its profits. If firm 1 wishes to act as a leader, it supposes that firm 2's reaction function is valid and incorporates it in profit function, as depicted below:

$$\pi_1 = h_1(y_1, \psi(y_1)). \tag{3.14}$$

Now, as we seen in Equation 3.14, firm 1's profit functions depends on y_1 as variable and therefore it can be maximised (HENDERSON; QUANDT, 1976). There is only the need to choose which one is suppose to be the leader and then replace the right variable for a reaction

function to achieve the solution for a Stackelberg model. Each duopolist determines maximum level of profit by deploying the strategy most suited for it, leader or follower, concerning which one is going to give a more high level of profits. There are four possibilities for firms in this scenario: (i) firm 1 is the leader, firm 2 follower; (ii) firm 2 is the leader, firm 1 follower; (iii) both firms want leadership over the market; and (iv) both firms wish to be followers. Stackelberg solution becomes a Cournot one if both firms wish to deploy follower strategy at the same time. Disequilibrium of Stackelberg happens whenever both firms try to be the leader and therefore reaction functions are not met. Stackelberg himself thought that this disequilibrium was very common resulting in economic war between firms leading ultimately to the collapse of one firm or resulting in a collusion agreement (HENDERSON; QUANDT, 1976, p. 224). Both duopolists wish to act as leader, inasmuch as they gain higher profits. As a result of a change in the behavioural basic principles a example where Cournot's equilibrium is easily achieved turn out to be a Stackelberg disequilibrium (HENDERSON; QUANDT, 1976).

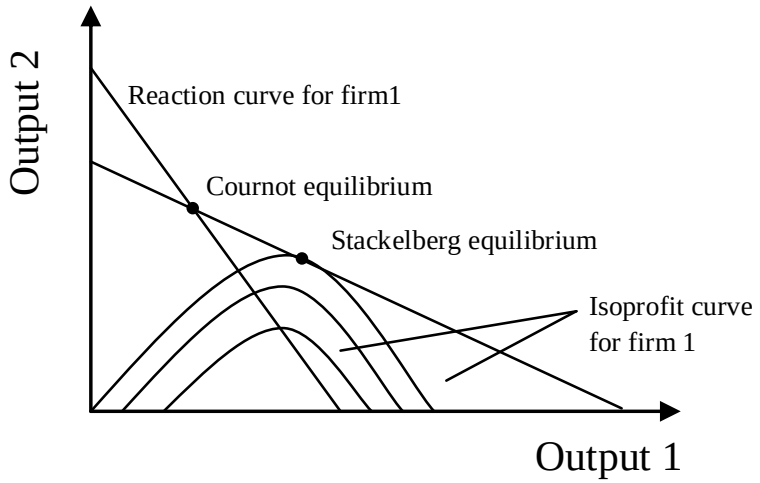


Figure 3.1 – Comparison of Cournot and Stackelberg equilibria — the Nash equilibrium takes place where the two reaction curves meet. While the Stackelberg equilibrium occurs where one reaction curve touches, i.e. is tangent, to the isoprofit curves of the other firm. Source: Varian (1992, p. 296).

3.3.1 The market-shares solution

The market-shares solution assumes that a follower firm wishes to keep a fixed market share, no matter what results come in the short run. This market has product differentiation (products are close substitutes, yet not perfect substitutes). The idea behind this solution is that this particular firm behaves glancing at the long run benefits of such strategy choice. Any changes made by the leader are immediately followed, with the purpose of guaranteeing the proportionality of the market share. The leader's maximum profit is a function varying only

with quantity, as long as the follower firm reacts in order to keep the fixed market share (HENDERSON; QUANDT, 1976).

3.4 Do Google, Apple and Microsoft collude?

Until now, models were basically non-cooperative games, hence firms acted independently from one another. Now, there will be experiences on what occurs to an industry structure where firms collude in setting their prices and outputs. Such industry is called a cartel, being actually a monopoly, even if maximization occurs and even if it acts as if there were two production plants.

Consider that in this model that both firms simultaneously choose output y_1 and y_2 in order to maximize the total industry profit:

$$\max_{y1,y_2} p(y_1 + y_2)[y_1 + y_2] - c_1(y_1) - c_2(y_2). \tag{3.15}$$

The first-order conditions are:

$$\begin{aligned} p(y_1^* + y_2^*) + p'(y_1^* + y_2^*)[y_1^* + y_2^*] &= c_1^{'}(y_1^*) \\ p(y_1^* + y_2^*) + p'(y_1^* + y_2^*)[y_1^* + y_2^*] &= c_2^{'}(y_2^*). \end{aligned} \tag{3.16}$$

In equilibrium, firms must equate their marginal costs. If one firm has a cost advantage (lower marginal cost), therefore it will produce more output in equilibrium in the cartel solution.

$$\begin{aligned} \frac{\partial \pi_1(y_1*, y_2)}{\partial y_1} &= p(y*_1 + y*_2) + p'(y*_1 + y*_2) - c_1'(y*_1), \\ \frac{\partial \pi_1(y_1*, y_2)}{\partial y_1} &= -p'(y*_1 + y*_2,)y*_2 > 0. \end{aligned} \tag{3.17}$$

As noted by Varian (1992) the equal sign in this expression comes from the first-order conditions in equations, and the inequality comes from the fact that demand curves slope downward.

A cartel solution is not a "stable" one, since there is always a temptation to cheat. If firm 1 increases its output thinking that firm 2 will stick with the quota agreed beforehand firm 1 benefits from a higher profit $\partial \pi_1 / \partial y_1 > 0$.

> "The strategic situation is similar to the Prisoner's Dilemma: if you think that other firm will produce its quota, it pays you to defect - to produce more than your quota. And if you thinks the other firm will not produce at its quota, then it will in general be profitable for you to produce more than your quota" (VARIAN, 1992, p. 304).

So, in the real world the problem a cartel faces is how to avoid cheating behaviour through the appropriate punishment.

When comparing with a Cournot solution, it is clear that a duopoly in collusion produces less output at a higher price and absorbs more profit. Returning to the problem, retaining that

in mind - which type of oligopoly strategies Google, Apple and Microsoft will be confronting? One may be assertive in stating that a cartel solution is not feasible for this industry. First of all, it is known that cheating is a very attractive behaviour when firms collude, but in the software industry it can be even more attractive. Given that informational goods have a high fixed cost though low marginal cost, this means that to replicate a software is very cheap, yet to develop it from scratch is expensive. Therefore, once you have developed a software, it is very easy for the firm to just increase its production, breaking free from the collusion. It can be observed how a firm can benefit from cheating by looking at this inequality $\partial\pi_1/\partial y_1 > 0$. It shows the possibility of achieving higher profits by just increasing output y_1. Also, in a one-shot game, achieving cooperation is very difficult to begin with (see the prisoners dilemma), hence it could be assumed that those firms would not collude.

Now, instead of considering a one-shot game, an example of an indefinitely repeated game is developed. Besanko et al. (2009) introduces the *folk theorem* in a scenario where one competitor raises its price to the monopoly level. The *folk theorem* says that for sufficiently low discount rates, any price between the monopoly price, p_M and marginal cost can be sustained as an equilibrium in the infinitely repeated prisoner's dilemma game. Consider the benefit-cost condition:

$$\frac{\frac{1}{N}[\pi_M - \pi_0]}{\pi_0 - \frac{1}{N}\pi_M} \geq i \tag{3.18}$$

"If this condition holds, each firm will independently, i.e. without collusion, raise price to the monopoly level" (BESANKO et al., 2009, p. 271). Equation 3.18 indicate that if each firm is looking at the long run, the discount rate i is not too large, then cooperative outcome will be sustainable (BESANKO et al., 2009). *Folk theorem* establishes that in a oligopolistic industry price coordination behaviour can arise even if all firms act unilaterally.

3.5 Which of the classic models of duopoly is correct?

The answer must be empirical, according to Kreps (1990, p. 338). Even after a complete review of the different prediction involved in the models of Cournot, Bertrand and Stackelberg, the study of strategies do not empower someone to be certain that those models cover all cases in real oligopoly. This does not mean that the classic models of oligopoly have no use at all. Instead, it demonstrates that there are a myriad of features involved in real case studies. As a consequence, a simple one-shot game cannot be expected to cover all real life cases. Moreover, utilizing the classic oligopoly theory to look for mechanisms that resemble the predictions of Cournot, Bertrand and Stackelberg might seem a bit odd. Still on theoretical grounds, certain characteristics might go well with certain predictions by one of the classic models (KREPS, 1990, p. 338). In the current work, the efforts were driven with the intention to cover the main

long lasting contributions inherited by economic theory from Cournot, Bertrand and Stackelberg.

CONCLUSIONS AND FUTURE WORK

This work presented a review of the main contributions on oligopoly theory in the course of the last two centuries. The theoretical predictions proposed by Cournot, Bertrand, and Stackelberg, concerning strategic behaviour of firm are benchmark models in today's textbooks. Static oligopoly theory is suitable to predict capacity expansion and price rivalry. Meanwhile, establishing if an industry follows a Cournot, Bertrand, or Stackelberg model is somewhat subjective, as the tactical manoeuvres can change the environment and also the firm's behaviour. This work proposed that economical principles need not to change when analysing technology firms. Additionally, this work established that an aggressive firm behaviour is captured by an unique attempt to gain consumers into their installed consumer base.

Google's hypothetical behaviour can be confirmed by data. Therefore, Google's free-of-charge policy can be classified as a short-run tactic of increasing their installed base for a long-run profit maximising strategy. The reason behind Google's free-of-charge policy is that, in order to steal consumers from competition, newcomers will set a lower price so as to offer consumers an attractive benefit-cost proposition. Also, Google's free-of-charge policy can be explained by the switching cost effect. A closer glance at Shapiro's model showed that consumers are not deceived by lower prices because of the assumption of quality assuring price, and below that, consumers will not believe that firms are producing high-quality goods. Apple is less willing to compete on price to gain a more robust consumer installed base. If an established firm such as Apple cuts on prices to attract new consumers, it reduces its profit margin on sales to its existing consumers. Apple increased the consumer base because of the high quality that consumers associated with iMac, iPod, iTunes, and Mac OS X goods. Thus, these products created a critical mass, increasing the network effect for the iPhone. Lock-in was achieved due to positive experience with a Apple's brand.

Tough commitment leading to long lasting monopolist position and behaviour is in the core of Microsoft since they signed the first contract with IBM. Theoretical findings corroborate Microsoft's behaviour because commitment can have two effects on profitability: a direct effect and a strategic one. While the strategic effect may alter market equilibrium, the direct effect has an impact on the present value of the firm's profits. Microsoft's contract with Nokia signalises the three characteristics that must be attended when making a commitment, because it is visible, understandable and credible. Additionally, Microsoft's choice of an inflexible strategy was a valuable tool when altering its competitors expectations about how it will compete.

It has been demonstrated that theoretical findings assure that what is being considered as strategy in this work has to do with decision making that last for some period of time.

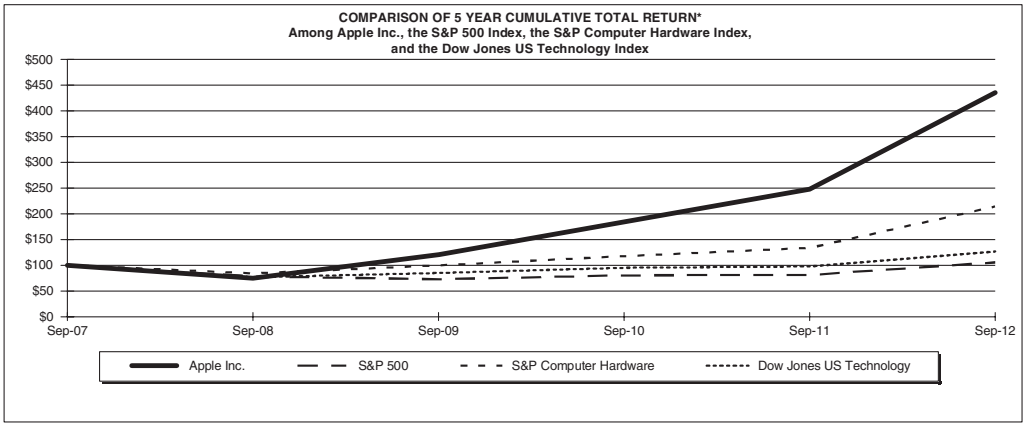
Finally, further work must be addressed when defining the perfect substitutability of the three operating systems, since even though the three conditions tend to hold, when accessing close substitutes can be helpful, they are certainly subjective. Econometric work, considering the cross-price elasticity of demand measuring the degree in which these goods substitute for each other must be developed in order to better ascertain the case of perfect substitutability.

APPENDIX A – APPLE INC.

Figure A.1 – Apple Inc. stock performane

Company Stock Performance

The following graph shows a five-year comparison of cumulative total shareholder return, calculated on a dividend reinvested basis, for the Company, the S&P 500 Composite Index, the S&P Computer Hardware Index, and the Dow Jones U.S. Technology Index. The graph assumes $100 was invested in each of the Company's common stock, the S&P 500 Composite Index, the S&P Computer Hardware Index, and the Dow Jones U.S. Technology Index as of the market close on September 30, 2007. Data points on the graph are annual. Note that historic stock price performance is not necessarily indicative of future stock price performance.



*$100 invested on 9/30/07 in stock or index, including reinvestment of dividends.
Fiscal year ending September 30.

	September 30, 2007	September 30, 2008	September 30, 2009	September 30, 2010	September 30, 2011	September 30, 2012
Apple Inc.	$100	$74	$121	$185	$248	$437
S&P 500	$100	$78	$ 73	$ 80	$ 81	$105
S&P Computer Hardware	$100	$84	$ 99	$118	$134	$214
Dow Jones US Technology	$100	$76	$ 85	$ 95	$ 98	$127

Source: Annual report, (APPLE, 2012, p. 23)

Table A.1 – Apple Inc net sales

Net Sales

The following table shows net sales by operating segment and net sales and unit sales by product during 2012, 2011, and 2010 (dollars in millions and units in thousands):

	2012	Change	2011	Change	2010
Net Sales by Operating Segment:					
Americas net sales	$ 57,512	50%	$ 38,315	56%	$24,498
Europe net sales	36,323	31%	27,778	49%	18,692
Japan net sales	10,571	94%	5,437	37%	3,981
Asia-Pacific net sales	33,274	47%	22,592	174%	8,256
Retail net sales	18,828	33%	14,127	44%	9,798
Total net sales	$156,508	45%	$108,249	66%	$65,225
Net Sales by Product:					
Desktops (a)(i)	$ 6,040	(6)%	$ 6,439	4%	$ 6,201
Portables (b)(i)	17,181	12%	15,344	36%	11,278
Total Mac net sales	23,221	7%	21,783	25%	17,479
iPod (c)(i)	5,615	(25)%	7,453	(10)%	8,274
Other music related products and services (d)	8,534	35%	6,314	28%	4,948
iPhone and related products and services (e)(i)	80,477	71%	47,057	87%	25,179
iPad and related products and services (f)(i)	32,424	59%	20,358	311%	4,958
Peripherals and other hardware (g)	2,778	19%	2,330	28%	1,814
Software, service and other sales (h)	3,459	17%	2,954	15%	2,573
Total net sales	$156,508	45%	$108,249	66%	$65,225
Unit Sales by Product:					
Desktops (a)	4,656	0%	4,669	1%	4,627
Portables (b)	13,502	12%	12,066	34%	9,035
Total Mac unit sales	18,158	9%	16,735	22%	13,662
iPod unit sales	35,165	(17)%	42,620	(15)%	50,312
iPhone units sold	125,046	73%	72,293	81%	39,989
iPad units sold	58,310	80%	32,394	334%	7,458

(a) Includes revenue from iMac, Mac mini and Mac Pro sales.
(b) Includes revenue from MacBook, MacBook Air and MacBook Pro sales.
(c) Includes revenue from iPod sales.
(d) Includes revenue from sales from the iTunes Store, App Store, and iBookstore in addition to sales of iPod services and Apple-branded and third-party iPod accessories.
(e) Includes revenue from sales of iPhone, iPhone services, and Apple-branded and third-party iPhone accessories.
(f) Includes revenue from sales of iPad, iPad services, and Apple-branded and third-party iPad accessories.
(g) Includes revenue from sales of displays, networking products, and other hardware.
(h) Includes revenue from sales of Apple-branded and third-party Mac software, and services.
(i) Includes amortization of related revenue deferred for non-software services and embedded software upgrade

Source: Annual report, (APPLE, 2012, p. 30)

APPENDIX B – GOOGLE INC.

Table B.1 presents the unaudited quarterly results of operatings for the eight quarters ended December 31, 2012. Table B.1 includes all adjustments, consisting only of normal recurring adjustments, that were considered by Google necessary for fair presentation of their consolidated financial position and operating results for the quarters presented. Both seasonal fluctuations in the internet usage and traditional retail seasonality have affected, and are likely to continue to affect, Google's business. Internet usage generally slows during the summer months, and commercial queries typically increase significantly in the fourth quarter of each year. These seasonal trends have caused and will likely continue to cause, fluctuations in our quarterly results, including fluctuations in sequential revenue growth rates (GOOGLE, 2012, p. 38).

Table B.1 – Google net sales

	Quarter Ended							
	Mar 31, 2010	Jun 30, 2010	Sep 30, 2010	Dec 31, 2010	Mar 31, 2011	Jun 30, 2011	Sep 30, 2011	Dec 31, 2011
	(In millions, except per share amounts) (unaudited)							
Consolidated Statements of Income Data:								
Revenues	$6,775	$6,820	$7,286	$8,440	$8,575	$9,026	$9,720	$10,584
Costs and expenses:								
Cost of revenues	2,452	2,467	2,552	2,946	2,936	3,172	3,378	3,702
Research and development	818	898	994	1,051	1,226	1,234	1,404	1,298
Sales and marketing	607	629	661	902	1,026	1,091	1,204	1,268
General and administrative	410	461	532	559	591	648	676	809
Charge related to the resolution of Department of Justice investigation	0	0	0	0	500	0	0	0
Total costs and expenses	4,287	4,455	4,739	5,458	6,279	6,145	6,662	7,077
Income from operations	2,488	2,365	2,547	2,982	2,296	2,881	3,058	3,507
Interest and other income (expense), net	18	69	167	160	96	204	302	(18)
Income before income taxes	2,506	2,434	2,714	3,142	2,392	3,085	3,360	3,489
Provision for income taxes	551	594	547	599	594	580	631	784
Net income	$1,955	$1,840	$2,167	$2,543	$1,798	$2,505	$2,729	$ 2,705
Net income per share:								
Basic	$ 6.15	$ 5.78	$ 6.80	$ 7.95	$ 5.59	$ 7.77	$ 8.44	$ 8.34
Diluted	$ 6.06	$ 5.71	$ 6.72	$ 7.81	$ 5.51	$ 7.68	$ 8.33	$ 8.22

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Source: Annual report (GOOGLE, 2012, p. 38)

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