COMPETITION OF HARDWARE MANUFACTURERS, PROPRIETARY AND FREE SOFTWARE DEVELOPERS, AND PIRATES

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ABSTRACT

The aim of this paper is to explain the structure of the market of hardware, proprietary and free software, and illegal copies of proprietary software.

We propose a simple model of market interactions between hardware vendors, proprietary and free software developers, and pirates. We consider two hardware suppliers, Intel and AMD, both maximize profits forming a traditional duopoly, while proprietary software supplier, Microsoft, and the community of free software developers, Linux team, form a mixed duopoly, in which only the first party maximizes its profit. We assume that there are also pirates maximizing profits of selling illegal copies of proprietary software.

It is shown that the price of the most expensive product (Microsoft Windows operating system) at the Cournot equilibrium is approximately ten times greater than the price of the cheapest product (AMD CPU), illegal copies of proprietary software are two times cheaper than legal copies of the same software, the profit of Microsoft is approximately five times greater than the profit of Intel, and approximately twenty times greater than the profit of AMD, and integrated profit of pirates is 26% greater than the profit of Intel. The market share of Intel is two times greater than the market share of AMD, and 33% greater than the market share of Microsoft Windows; the market share of Microsoft Windows is 33% greater than the market share of Microsoft Office; the market shares of Microsoft Windows and Microsoft Office illegal copies are two times smaller than the market shares of corresponding legal copies.

INTRODUCTION

Over the recent years, an increasing large number of industries have evolved from vertical to horizontal integration, where some firms design and manufacture components which are assembled by other firms for the final customers. In these horizontal industries, firms are ‘complementors’ rather than customers, suppliers, or competitors. IT industry demonstrates the most striking examples of such an organization. There are suppliers of hardware components (processors, memory modules, motherboards, video cards, monitors, drives, etc.), suppliers of software (operating systems, office suites, etc.), and assemblers of computers providing the market with servers and workstations (usually with preinstalled software). For example, CPUs could be made by *Intel* or *AMD*, PCs could be assembled by *ASUS*, *Dell*, *Hewlett Packard* and others, on the same computer one of operating systems can be installed (e. g., *Microsoft Windows* or *Linux*), and various applications can work under different operating systems (e. g., *Microsoft Office* and *OpenOffice*).

The horizontal integration of IT industry is linked to setting up an open standard for *IBM PC* in 1980. As a result, there was a deep specialization of component manufacturers, assemblers, and software developers. In particular, the *IBM*’s decision of choosing *Intel* and *Microsoft* as manufacturers of CPUs and operating systems as the key PC components has led to *Intel* and *Microsoft* domination at the PC market for almost 30 years (in contrast to *IBM*, which has lost its strategic positions in this market).

According to Casadesus-Masanell, Nalebuff and Yoffie (2007a), in 2007 more than 80% of the PCs worldwide were shipped with an *Intel* CPU running *Microsoft Windows* operating system while there are a lot of producers of other PC components (motherboards, memory modules, drives, monitors, etc.) in this market.

As it was demonstrated by Yoffie, Casadesus-Masanell and Mattu (2004), the combined profit of *Intel* and *Microsoft* during most years in the 1990s exceeded the total profit of the entire world PC industry.

In 2004, for example, *Intel* and *Microsoft* earned over $15B in net profits while the three largest assemblers (*Dell*, *HP* and *IBM*) made roughly just $2.5B in profits from their PC operations. IBM alone lost over $1B in PCs in 1998, and another $1B between 2001 and 2004. Only *Dell* made material profits in the PC industry at that time. For more detailed information on market dynamics see Yoffie, Casadesus-Masanell and Mattu (2004).

This gives us the reason to assume *Microsoft* and *Intel* the key strategic players in the market of PCs that have a direct impact on the final product price (unlike the manufacturers of the other components).

Unlike the microprocessor market, where the main player (*Intel*), and its closest competitor (*AMD*), and other manufacturers seek to maximize their profits, the modern software market is characterized by the asymmetry of suppliers' interests, some of the software suppliers are maximizing their profits from the sale of licenses for their products (like *Microsoft*), while other software developers are distributing their products for free, often even with open source code.

For example, for-profit manufacturers had a monopoly in the server operating systems market 15 years ago, because the users did not trust non-commercial software that did not guarantee quality, reliability and security; now the commercial software product *Microsoft Windows* and its non-commercial competitor *Linux* each have approximately 40% of the server operating systems market. In contrast to *Microsoft*, the *Linux* developers community distributes this operating system for free and with open source code under *GNU GPL* license).

The competition in the software market essentially differs from a competition in the markets of traditional material goods (including CPUs) due to the special features of software as a good, first of all, due to the absence of rarity.

At the moment all the software users are choosing between the three options:

- to buy licenses and use the commercial proprietary software (e. g. *Microsoft Windows* as an operating system, *Microsoft Office* as an office suite, *Microsoft SQL Server* as a database server, *Microsoft Internet Information Server* as a web server, etc.);
- to use free or open source software (e. g. *Linux* as an operating system, *OpenOffice* as an office suite, *MySQL* as a database server, *Apache* as a web server, etc.);
- to use illegal (pirate) copies of proprietary software without buying licenses.

These three options correspond to the following three types of software market players:

- profit-maximizers (for example, *Microsoft*);
- non-for-profit players (for example, *Linux* team);
- pirates.

Correspondingly, the software developers try to determine the optimal way of income collecting:

- to sell the licenses for the use of their products;
- or to distribute the products for free and to collect incomes from sales of additional services.

As the real market shows, there is no unambiguous answer for the formulated questions. There are whole countries, using illegal copies of the proprietary software almost at 100%.

The number of non-commercial software users grows, and software developers that distribute their products with open source code receive stable incomes.

But the number of commercial software users remains high, allowing for-profit suppliers to receive a steady income from the sales of licenses.

Such a market structure requires new approaches to research methodology as well as to business development methodology.

The aim of this paper is to explain the structure of the market of hardware, proprietary and free software, and illegal copies of proprietary software.

We propose a model of market interactions between hardware vendors, proprietary and free software developers, and pirates. We consider two hardware suppliers, *Intel* and *AMD*, both maximize profits forming a traditional duopoly, while proprietary software supplier, *Microsoft*, and the community of free software developers, *Linux* team, form a mixed duopoly, in which only the first party maximizes its profit. We assume that there are also pirates maximizing profits of selling illegal copies of proprietary software. The model will be used to calculate the optimal pricing strategies and market shares for all the products.

LITERATURE REVIEW

A. Cournot in the seminal book (1838) has considered the first model in mathematical economy for interactions between monopolists producing complementary products (manufacturers of copper and zinc that are combined to make a brass as a composite product). The main result developed by Cournot using this model of complementary products suppliers' interaction is that suppliers will divide the profits equally non-depending on the relation of the components prices!

However, in the real IT market there is a competition both between hardware manufacturers (there are *Intel*-based and *AMD*-based servers and workstations in the market), and between of operating systems suppliers (*Microsoft Windows* and *Linux*).

While price competition between vertically differentiated goods as well price competition between complementors are each well understood in mathematical economics, but the combined case of competition between competing complements is investigated insufficiently and needs additional research.

McAfee, McMillan and Whinston (1989) studied game-theory model of packaging products into a bundle and obtained conditions when bundling is an optimal strategy for the suppliers. Developing this research Choi and Stefanadis (2001), and Nalebuff (2004) investigated a question on expediency of entering into the market with a composite product.

Brandenburger and Nalebuff (1996) have considered *Intel* and *Microsoft* as an example of players who co-operate and compete simultaneously, they even have introduced the term '*Co-Opetition'* for a designation of interaction of players of this kind.

Casadesus-Masanell and Yoffie (2006) suggested the game model for the situation of co-operation and competition of *Intel* and *Microsoft*, and as a result of research it has appeared that unlike Cournot model where both manufacturers divide the profits fifty-fifty, in this case the optimal strategy of Microsoft is to underprice in order to increase the client base, but Intel in reply to it should simply overprice and get the additional profit because an operating system is not on sale separately from a PC (see also the case study by Yoffie, Casadesus-Masanell and Mattu (2004).

Farrell and Katz (2000) have considered a situation, when the exclusive manufacturer of one component enters into the competitive market of the second component in order to reduce its price, and as a consequence, the price of a composite product. This model can be applied to *Intel* activities on motherboards manufacturing in addition to CPUs, but not to interactions of software and hardware manufacturers.

Cheng and Nahm (2007) have considered Stackelberg's strategy in a situation of cooperation and competition of exclusive manufacturers of two components, each of which can be used as a part of a composite product, and separately. In the IT market using of one component (hardware or software) without another is impossible, and in addition there is a competition between manufacturers of components.

Chen, Nalebuff and Nalebuff (2006) have investigated competitive interactions in markets with one-way essential complements (first product is essential to the use of the second product, but can be used without the second product). Chen, Nalebuff and Nalebuff have applied this model to study the market of operating systems and applied software. They have shown that it is favourable to operating systems developer to enter into the competitive market of applied software with a competing version of application and to sell it at zero price. As a result, the existing competitors in the applied software market will be compelled to join the monopoly.

One of the recent steps in the duopoly theory was to combine the classic market duopoly theory with the demand-side learning and to extend this approach to a dynamic situation where the objectives of players are mixed rather than symmetric. This step was done by Cassadesus-Masanell and Ghemawat (2006) who have proposed a dynamic mixed duopoly model and applied this model to *Windows*/*Linux* competition dynamics.

Using the optimal control theory Casadesus-Masanell and Ghemawat (2006), and (with some extensions) Soloviev (2008, 2009) have obtained the conditions when *Linux* and *Windows* coexist in the market, and when one of the products is pushed out by another.

Casadesus-Masanell, Nalebuff and Yoffie (2008) have presented a model of interaction of two competing hardware suppliers (*Intel* and *AMD*) with the exclusive operating systems manufacturer (*Microsoft*). This work represents, as a matter of fact, the first research of a competing complements. This paper considers competition between suppliers of complementing components (*Intel* and *Microsoft*), and between competing suppliers of similar components (*Intel* and *AMD*).

Soloviev (2009a, 2009b, 2009d) has extended the Casadesus-Masanell, Nalebuff and Yoffie (2008) model to interaction of two competing hardware suppliers (*Intel* and *AMD*) with two competing operational systems manufacturers, *Microsoft* corporation (the developer of proprietary *Windows* operating system), and non-commercial *Linux* operating system developers community. Soloviev, Iliina and Samoyavcheva (2009a, 2009b) have considered a Cournot situation in this model, when each of the profit-maximizing suppliers sets the price based on available market information on other players' products prices in the previous time moment, and assuming the cross-price elasticities to zero. At the Cournot equilibrium, an *Intel*-based PC running *Windows* is 5 times more expensive than *AMD*-based PC running *Linux*; an *Intel* CPU costs 2 times more than *AMD* processor; *Windows* license is 1,5 times more expensive than *Intel* processor; the profit of *Intel* is 4 times greater than the profit of *AMD*, and *Microsoft*'s profit is 12,5% greater than *Intel*'s profit.

In this paper we want to take software piracy into account.

ASSUMPTIONS

Let's discuss the basic assumptions of hardware and software suppliers' interactions model.

1. The bundle of hardware (a PC) with operating system and office suite is selling in the market. There are *Intel*-based and *AMD*-based PCs in the market, each of which can be selling with legal or illegal copy of *Windows,* or copy of *Linux*. Legal copies of *Windows* operating system are distributing by *Microsoft* corporation on a commercial basis by selling licenses, while *Linux* operating system is distributing by *Linux* developers community freely and free of charge. The user can install legal or illegal copy of *Microsoft Office*, or copy of free *OpenOffice* product on Windows-running PC, and he or she can install only *OpenOffice* product on *Linux*-running PC. There is integrated pirating agent at the market who sells illegal copies of proprietary *Microsoft Windows* operating system and *Microsoft Office* suite.

Thus, the user selects one of 14 products:

- *Intel* / *AMD*-based PC running legal *Microsoft Windows* / illegal *Microsoft Windows* with legal *Microsoft Office* / illegal *Microsoft Office* / *OpenOffice*;
- *Intel* / *AMD*-based PC running *Linux* with *OpenOffice*.

2. Nowadays, the *Windows* / *Linux* competition, especially in the netbooks segment, is growing because the *Windows* license costs more than 10% of the final product price for many models. Although the *Windows* license price and the price of *Windows* illegal copy are positive, and *Linux* is distributed freely, three products co-exist at the market. It means that a consumer values legal *Windows* greater than illegal *Windows,* and illegal *Windows* greater than *Linux*. *Intel*-based PCs occupy the largest market share, so a consumer values *Intel*-based PC greater than *AMD*-based PC. It is supposed also that the difference in consumer value of different hardware is less, than a difference in consumer value of identical hardware with different operating systems.

3. The demand functions for the combined products are linear, and the user will buy the bundled product (a PC with an operating system) if and only if the consumer value of this product for this user exceeds its price.

4. The hardware and software prices are made up of fixed costs, manufacturer's profit, variable costs and technical support costs. The hardware manufacturer needs to build a hi-tech plant which costs several billion dollars in order to produce CPUs, but then the production of a CPU costs less than 1 dollar. The software developer needs some investment to develop the product, but after that it does not cost too much to burn a CD, and it costs almost nothing to release the product in the Internet. So, fixed costs are essentially greater for hardware manufacturers than for software developers, and variable costs are close to zero. Technical support costs for hardware and software manufacturers are approximately the same. Pirates have no fixed costs and technical support costs, and their variable costs are close to zero. Products are offered in the market during quite a long time without essential changes of functionality. In other words, manufacturers incur fixed costs just once, then collect them back by manufacturing and selling products, then start to receive net profits. Therefore it is possible to assume that *Intel*, *AMD*, *Microsoft* , and pirates make their pricing decisions based on the aim of maximization of instant profits, i. e. profits calculated taking into account variable, but not fixed costs.

5. Hardware and software manufacturers do not conspire and do not co-operate in other ways. Each manufacturer makes the pricing decisions based on available market information on the prices of other players' products (i. e., Cournot situation is considered).

6. When making pricing decisions each manufacturer considers that other players do not react on the change of the price by this manufacturer, i.e. cross price elasticities are equal to zero.

7. The prices of all the products essentially exceed variable costs for these products manufacturing.

8. PC assemblers form the market of a perfect competition, and could not affect the price of the bundled product (a PC with an operating system), unlike manufacturers of CPUs and the proprietary operating system. We assume that illegal copies of *Windows* are selling by an integrated economic agent. It is assumed that the bundled product price is the sum of the CPU price and the operating system price.

Let's use the following designations: $q_{\max}$ — PC market capacity; P_{A+L+O}, P_{A+W+M}, P_{A+W+O}, P_{A+W+PO}, P_{A+PW+M}, P_{A+PW+O}, $P_{A+PW+PO}$, P_{I+L+O}, P_{I+W+M}, P_{I+W+O}, P_{I+W+PO}, P_{I+PW+M}, P_{I+PW+O} and $P_{I+PW+PO}$ — maximal possible prices for *Intel* / *AMD*-based PC running legal / illegal *Microsoft Windows* with legal / illegal *Microsoft Office* or *OpenOffice*; p_I and p_A — prices for *Intel* and *AMD* CPUs set by manufacturers; p_W and p_M — *Microsoft Windows* and *Microsoft Office* license prices set by *Microsoft*; p_{PW} and p_{PM} — prices for illegal copies of *Microsoft Windows* and *Microsoft Office* set by the integrated pirating agent; q_{A+L+O}, q_{A+W+M}, q_{A+W+O}, q_{A+W+PO}, q_{A+PW+M}, q_{A+PW+O}, $q_{A+PW+PO}$, q_{I+L+O}, q_{I+W+M}, q_{I+W+O}, q_{I+W+PO}, q_{I+PW+M}, q_{I+PW+O} and $q_{I+PW+PO}$ — demand on the products; f_I, f_A and f_M — fixed costs of *Intel*, *AMD, Microsoft*; v_I, v_A, v_W, v_M, v_{PW} and v_{PO} —variable costs on manufacturing *Intel* and *AMD* CPUs, legal / illegal copies of *Microsoft Windows* and *Microsoft Office*; π_I, π_A, π_M and π_P — profits of *Intel*, *AMD, Microsoft* and the integrated pirating agent.

MODEL

In the formulated assumptions the model of hardware and software manufacturers' interaction looks as follows

(1)

$$\begin{cases} q_j = q_{\max}(1 - p / P_j), \\ \quad j \in \{A+L+O,\, A+W+M,\, A+W+O,\, A+W+PO,\, A+PW+M,\, A+PW+O,\, A+PW+PO, \\ \quad\quad I+L+O,\, I+W+M,\, I+W+O,\, I+W+PO,\, I+PW+M,\, I+PW+O,\, I+PW+PO\}; \\ q_A = q_{A+L+O} + q_{A+PW+O} + q_{A+PW+PO} + q_{A+PW+M} + q_{A+W+O} + q_{A+W+PO} + q_{A+W+M}, \\ q_I = q_{I+L+O} + q_{I+PW+O} + q_{I+PW+PO} + q_{I+PW+M} + q_{I+W+O} + q_{I+W+PO} + q_{I+W+M};\;\; q_L = q_{I+L+O} + q_{A+L+O}, \\ q_W = q_{I+W+O} + q_{I+W+PO} + q_{I+W+M} + q_{A+W+O} + q_{A+W+PO} + q_{A+W+M},\;\; q_M = q_{I+PW+M} + q_{I+W+M} + q_{A+PW+M} + q_{A+W+M}, \\ q_{PW} = q_{I+PW+O} + q_{I+PW+PO} + q_{I+PW+M} + q_{A+PW+O} + q_{A+PW+PO} + q_{A+PW+M}; \\ q_{PO} = q_{I+PW+PO} + q_{I+W+PO} + q_{A+PW+PO} + q_{A+W+PO},\;\; q_O = q_{I+L+O} + q_{I+PW+O} + q_{I+W+O} + q_{A+L+O} + q_{A+PW+O} + q_{A+W+O}, \\ \pi_I = q_I(p_I - v_I) - f_I \to \max,\quad \pi_A = q_A(p_A - v_A) - f_A \to \max, \\ \pi_M = q_W(p_W - v_W) + q_M(p_M - v_M) - f_M \to \max,\quad \pi_P = q_{PW}(p_{PW} - v_{PW}) + q_{PO}(p_{PO} - v_{PO}) \to \max. \end{cases}$$

The most simple case is when all the P_j are equal to some constant P and all the variable costs are equal to zero. In this case we have

(2)

$$\begin{cases} q_{I+W+M} = q_{\max}\left(1 - (p_I + p_W + p_M)/P\right), \\ q_{A+W+M} = q_{\max}\left(1 - (p_A + p_W + p_M)/P\right) - q_{\max}\left(1 - (p_I + p_W + p_M)/P\right) = q_{\max}(p_I - p_A)/P, \\ q_{I+W+PO} = q_{\max}\left(1 - (p_I + p_W + p_{PO})/P\right) - q_{\max}\left(1 - (p_A + p_W + p_M)/P\right) = q_{\max}(p_A + p_M - p_I - p_{PO})/P, \\ q_{A+W+PO} = q_{\max}\left(1 - (p_A + p_W + p_{PO})/P\right) - q_{\max}\left(1 - (p_I + p_W + p_{PO})/P\right) = q_{\max}(p_I - p_A)/P, \\ q_{I+W+O} = q_{\max}\left(1 - (p_I + p_W)/P\right) - q_{\max}\left(1 - (p_A + p_W + p_{PO})/P\right) = q_{\max}(p_A + p_{PO} - p_I)/P, \\ q_{A+W+O} = q_{\max}\left(1 - (p_A + p_W)/P\right) - q_{\max}\left(1 - (p_I + p_W)/P\right) = q_{\max}(p_I - p_A)/P, \\ q_{I+PW+M} = q_{\max}\left(1 - (p_I + p_{PW} + p_M)/P\right) - q_{\max}\left(1 - (p_A + p_W)/P\right) = q_{\max}(p_A + p_W - p_I - p_{PW} - p_M)/P, \\ q_{A+PW+M} = q_{\max}\left(1 - (p_A + p_{PW} + p_M)/P\right) - q_{\max}\left(1 - (p_I + p_{PW} + p_M)/P\right) = q_{\max}(p_I - p_A)/P, \\ q_{I+PW+PO} = q_{\max}\left(1 - (p_I + p_{PW} + p_{PO})/P\right) - q_{\max}\left(1 - (p_A + p_{PW} + p_M)/P\right) = q_{\max}(p_A + p_M - p_I - p_{PO})/P, \\ q_{A+PW+PO} = q_{\max}\left(1 - (p_A + p_{PW} + p_{PO})/P\right) - q_{\max}\left(1 - (p_I + p_{PW} + p_{PO})/P\right) = q_{\max}(p_I - p_A)/P, \\ q_{I+PW+O} = q_{\max}\left(1 - (p_I + p_{PW})/P\right) - q_{\max}\left(1 - (p_A + p_{PW} + p_{PO})/P\right) = q_{\max}(p_A + p_{PO} - p_I)/P, \\ q_{A+PW+O} = q_{\max}\left(1 - (p_A + p_{PW})/P\right) - q_{\max}\left(1 - (p_I + p_{PW})/P\right) = q_{\max}(p_I - p_A)/P, \\ q_{I+L+O} = q_{\max}\left(1 - p_I/P\right) - q_{\max}\left(1 - (p_A + p_{PW})/P\right) = q_{\max}(p_A + p_{PW} - p_I)/P, \\ q_{A+L+O} = q_{\max}\left(1 - p_A/P\right) - q_{\max}\left(1 - p_I/P\right) = q_{\max}(p_I - p_A)/P, \\ q_I = q_{\max}(P + 6p_A - 7p_I)/P,\;\; q_A = 7q_{\max}(p_I - p_A)/P,\;\; q_W = q_{\max}(P - p_A - p_W)/P, \\ q_M = q_{\max}(P - 2p_M - p_A - p_{PW})/P,\;\; q_{PW} = q_{\max}(p_W - p_{PW})/P,\;\; q_{PO} = 2q_{\max}(p_M - p_{PO})/P; \end{cases}$$

and

(3)

$$\begin{cases} \pi_I = q_{\max}(P + 6p_A - 7p_I)p_I/P - f_I \to \max,\;\; \pi_A = 7q_{\max}(p_I - p_A)p_A/P - f_A \to \max, \\ \pi_M = q_{\max}\left((P - p_A - p_W)p_W + (P - 2p_M - p_A - p_{PW})p_M\right)/P - f_M \to \max, \\ \pi_P = q_{\max}\left((p_W - p_{PW})p_{PW} + 2q_{\max}(p_M - p_{PO})p_{PO}\right)/P \to \max. \end{cases}$$

INVESTIGATION

We have the following first-order conditions (taking into account that we consider Cournot situation where manufacturer makes the pricing decisions assuming the prices of other players' products are constant, and all cross price elasticities are equal to zero):

(4) $\partial\pi_I / \partial p_I = 0 \Leftrightarrow P + 6p_A - 14p_I = 0,\quad \partial\pi_A / \partial p_A = 0 \Leftrightarrow p_I - 2p_A = 0,$

(5) $\begin{cases} \partial\pi_M / \partial p_W = 0, \\ \partial\pi_M / \partial p_M = 0 \end{cases} \Leftrightarrow \begin{cases} P - p_A - 2p_W = 0, \\ P - 4p_M - p_A - p_{PW} = 0, \end{cases} \quad \begin{cases} \partial\pi_P / \partial p_{PW} = 0, \\ \partial\pi_P / \partial p_{PO} = 0 \end{cases} \Leftrightarrow \begin{cases} p_W - 2p_{PW} = 0, \\ p_M - 2p_{PO} = 0. \end{cases}$

Now we can find the optimal prices, demand and profits:

(6) $$p_I^* = \frac{64P}{704},\ p_A^* = \frac{32P}{704},\ p_W^* = \frac{336P}{704},\ p_{PW}^* = \frac{168P}{704},\ p_M^* = \frac{126P}{704},\ p_{PO}^* = \frac{63P}{704},$$

(7) $$q_I^* = \frac{448q_{\max}}{704},\ q_A^* = \frac{224q_{\max}}{704},\ q_W^* = \frac{336q_{\max}}{704},\ q_{PW}^* = \frac{168q_{\max}}{704},\ q_M^* = \frac{252q_{\max}}{704},\ q_{PO}^* = \frac{126q_{\max}}{704},$$

(8) $$\pi_I^* = \frac{28672Pq_{\max}}{704^2} - f_I,\ \pi_A^* = \frac{7168Pq_{\max}}{704^2} - f_A,\ \pi_M^* = \frac{144648Pq_{\max}}{704^2} - f_M,\ \pi_P^* = \frac{36162Pq_{\max}}{704^2}.$$

RESULTS AND DISCUSSION

We can see that the price of the most expensive product (*Microsoft Windows* operating system) at the Cournot equilibrium is approximately ten times greater than the price of the cheapest product *(AMD* CPU), illegal copies of proprietary software are two times cheaper than legal copies of the same software, the profit of *Microsoft* is approximately five times greater than the profit of *Intel*, and approximately twenty times greater than the profit of *AMD*, and integrated profit of pirates is 26% greater than the profit of *Intel*. The market share of *Intel* is two times greater than the market share of *AMD*, and 33% greater than the market share of *Microsoft Windows*; the market share of *Microsoft Windows* is 33% greater than the market share of *Microsoft Office*; the market shares of *Microsoft Windows* and *Microsoft Office* illegal copies are two times smaller than the market shares of corresponding legal copies.

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