STANDARDS COMPETITION AND COOPERATION AT THE COMPUTER HARDWARE AND SOFTWARE MARKET

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ABSTRACT

The paper is motivated by competition and cooperation of hardware (Intel, AMD), operating systems (Microsoft Windows and Linux), and software applications (Microsoft Office and OpenOffice).

The objective of the paper is to show the conflicts in pricing and the frequency of new releases which is contrary to the general view of well aligned incentives of complementary network products.

The research of competing complementary products have started with the classic work of Cournot published in 1838. The usual modern approach in such studies is to consider network effects in complements competition as one-sided.

This paper presents some extensions and modifications of the dynamic model of Windows/Intel competition presented by Cassadesus-Masanell and Yoffie in 2007 who have introduced the two-sided network effects approach into research of competing complements. In this model the two-stage game is analyzed when at the first stage the competitors invest into R&D, and at the second stage they set prices. Cassadeus-Masanell and Ghemawat assumed that in each period of time a new “cohort” of potential users enters the market. We here measure the market size not in “cohorts” but in “users” assuming that the market is growing and in each period of time the fixed number of potential users enters the market.

Another extension to Cassadesus-Masanell and Ghemawat’s model brings into consideration competitive interactions between Microsoft Windows and Linux, Intel and AMD, Microsoft Office and OpenOffice.

The mechanism of the conflict is investigated when Intel sets prices too high and supports Linux team, the major competitor of Microsoft, while Microsoft releases new versions too late and backs AMD, Intel’s main competitor.

The investigation of hardware and software opposition provided in this paper is important for revealing the nature and mechanisms of competition at the knowledge markets. The model could be used as an instrument for decision-making at the IT market and as a basis for future research.

The assumption of linear market growth and particular attention given simultaneously to a conflicts between hardware and software manufacturers, competing software vendors, and competing hardware manufacturers form the basis of the model's originality.

INTRODUCTION

The paper is motivated by competition and cooperation of hardware (Intel, AMD), operating systems (Microsoft Windows and Linux), and software applications (Microsoft Office and OpenOffice).

The product at the personal workstations market is a combination of hardware and preinstalled operating system. At the modern PC workstations hardware market there is a duopoly of two manufacturers: Intel and AMD, and at the operating systems market there is a duopoly of commercial (proprietary) operating system Microsoft Windows and open source (free) OS Linux.
The software product cost is the sum of fixed cost, vendor profit (margin), variable cost and maintenance cost. Fixed costs of commercial and non-commercial software are quite small, variable costs of commercial and non-commercial software tend to zero (it costs almost nothing to write a CD or to put a release to Internet), maintenance costs of these two types of software are approximately equal, and the profit of commercial software vendor is positive while one of non-for-profit player is equal to zero. Non-for-profit players indeed earn their money but (opposed to profit-makers) not on sales but on maintenance.

The hardware product cost is also the sum of fixed cost, vendor profit, and maintenance cost, where fixed cost is relatively large, variable cost tend to zero (to produce a chip one should build a plant which is very expensive like several $M and then variable cost of one chip is less than $1), hardware maintenance cost is approximately equal to software maintenance cost, and the profit of hardware vendor is positive.

The objective of the paper is to show the conflicts in pricing and the frequency of new releases which is contrary to the general view of well aligned incentives of complementary network products.

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Some special attention to free software economics was put by Bitzer and Srhroder (2006), and the problem of Intel, Microsoft and Cisco leadership was diskussed by Gawer and Cusumano (2002).

The dynamic mixed duopoly of Linux and Windows was investigated by Casadesus-Masanell and Ghemawat (2006) and by Soloviev (2008a, 2008b). They combined the classic market duopoly theory with the demand-side learning and extended this approach to a dynamic situation where the objectives of players are mixed rather than symmetric.

Using the optimal control theory Casadesus-Masanell and Ghemawat (2006), and (with some extensions) Soloviev (2008a, 2008b) have obtained the conditions when Linux and Windows coexist at the market and when Linux is pushed out by Windows and vice versa are obtained and discussed. The special focus in these models was given to a piracy of Windows and strategic contribution to Linux issues.

This paper presents some extensions and modifications of the dynamic model of Windows/Intel competition presented by Cassadesus-Masanell and Yoffie in 2007 who have introduced the two-sided network effects approach into research of competing complements. In this model the two-stage game is analyzed when at the first stage the competitors invest into R&D, and at the second stage they set prices.

Casadeus-Masanell and Ghemawat assumed that in each period of time a new “cohort” of potential users enters the market. We here measure the market size not in “cohorts” but in “users” assuming that the market is growing and in each period of time the fixed number of potential users enters the market.

Another extension to Cassadesus-Masanell and Ghemawat’s model brings into consideration competitive interactions between Windows and Linux, Intel and AMD, Microsoft Office and OpenOffice.

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MODEL
We assume that Intel (denoted by $I$ bottom index in all the formulae) is a monopolist at the workstation hardware market, and there are two competing products at the operating systems market: Microsoft Windows (denoted by $M$) which is commercial (proprietary), and Linux (denoted by $L$) which is free. Hardware and operating system are strictly complementary products which means that the bundle “hardware + operating system” is valuable for the customer while neither a PC alone nor an OS alone have any value for the user. It is reasonable because every computer is selling with preinstalled operating system, and the competition between Windows and Linux grows because for example at cheap notebooks segment the price of Windows makes more than 10% of the price of the combined product while Linux is free.

The buyers at the market value Intel more than AMD and they value Windows more than Linux, that’s why Intel and Microsoft are not pushed out from the market but dominate there. AMD is cheaper than Intel, and Linux is free while the price of Windows license is positive that’s why AMD and Linux co-exist at the market with Intel and Microsoft.

Let us denote $q_{\text{max}}$ the size of the computer workstations market, $C_I$ the maximal price of a PC with Linux $C_{I+M}$ the maximal price of Intel-based PC with Windows (it is assumed that users value PC with Windows more than PC with Linux), and use the linear demand functions

(1) \[ q_{I+M}(c) = q_{\text{max}} \left( 1 - \frac{c}{C_{I+M}} \right), \]

and for Intel-based PC with Microsoft Windows

(2) \[ q_{I+L}(c) = q_{\text{max}} \left( 1 - \frac{c}{C_I} \right) \]

for the PC with Linux.

Then if Intel sets the price for a PC at $c_I$ and Microsoft sets the price for Windows at $c_M$ the demand for PCs with Windows will be

(3) \[ q_M = q_{\text{max}} \left( 1 - \frac{c_I + c_M}{C_I} \right), \]

and the demand for PCs with Linux will be

(4) \[ q_L = q_{\text{max}} \left( 1 - \frac{c_I}{C_I} \right) - q_{\text{max}} \left( 1 - \frac{c_I + c_M}{C_I} \right) = q_{\text{max}} \frac{c_M}{C_I}. \]

It means that a user will buy a PC with Windows if and only if he or she value this product more than its price (see Fig. 1).
Figure 1. Demand functions

The overall demand for Intel is

\[ q_I = q_{\text{max}} \left(1 - \frac{c}{C_I} \right) + q_{\text{max}} \frac{c_M}{C_I} = q_{\text{max}} \left(1 - \frac{c}{C_I} \right). \]

It is important that the demand on Linux-based PCs depends only on Windows price but not on the PC price, and overall demand for Intel depends only on Intel hardware price but not on the PC price, while the demand on Windows-based PCs depends on Windows price and on the hardware price!

If \( f_I \) and \( v_I \) are fixed and variable costs for Intel-based PC, and \( f_M \) and \( v_M \) are fixed and variable costs for Microsoft Windows, then we can state the problem of Intel:

\[ \pi_I = q_I (c_I - v_I) - f_I = q_{\text{max}} \left(1 - \frac{c}{C_I} \right) (c_I - v_I) - f_I \rightarrow \text{max}. \]

and the problem of Microsoft:
\( \pi_{M} = q_{M} \left( c_{M} - v_{M} \right) - f_{M} = q_{\text{max}} \left( 1 - \frac{c_{L} + c_{M}}{C_{I}} \right) \left( c_{M} - v_{M} \right) - f_{M} \rightarrow \text{max}. \)

Here \( \pi_{I} \) and \( \pi_{M} \) are the profits of Intel and Microsoft.

**INVESTIGATION**

The first-order conditions for Intel problem gives us its solution:

\[
\frac{d\pi_{I}}{dc_{I}} = 0 \Leftrightarrow q_{\text{max}} \frac{C_{I} - 2c_{I} + v_{I}}{C_{I}} = 0 \Leftrightarrow c_{I}^{*} = \frac{C_{I} + v_{I}}{2},
\]

and the maximal profit of Intel is

\[
\pi_{I}^{*} = q_{\text{max}} \left( \frac{C_{I} - v_{I}}{2} \right)^{2} - f_{I}.
\]

Then Microsoft’s best response function could be found from the following conditions:

\[
\frac{\partial \pi_{M}}{\partial c_{M}} \bigg|_{c_{I}^{*} - \text{const}} = 0 \Leftrightarrow q_{\text{max}} \left( \frac{C_{I} + v_{M} - c_{I}^{*} - 2c_{M}}{C_{I}} \right) = 0 \Leftrightarrow c_{M}^{*} = \frac{C_{I} + v_{M} - c_{I}^{*}}{2} \Leftrightarrow c_{M}^{*} = \frac{C_{I} + 2v_{M} - v_{I}}{4},
\]

and the maximal profit of Microsoft is

\[
\pi_{M}^{*} = q_{\text{max}} \left( \frac{C_{I} - 2v_{M} - v_{I}}{16C_{I}} \right)^{2} - f_{M}.
\]

**RESULTS**

We can see that

\[
\frac{\partial c_{M}^{*}}{\partial c_{I}} = -\frac{1}{2}
\]

which means that if Intel raise the price by $1 then Microsoft should cut the price by 50 cents.

Let us find the conditions when Intel’s profit is greatest than Microsoft’s:

\[
\pi_{I}^{*} > \pi_{M}^{*} \Leftrightarrow q_{\text{max}} \left( \frac{C_{I} - v_{I}}{2} \right)^{2} - f_{I} > q_{\text{max}} \left( \frac{C_{I} - 2v_{M} - v_{I}}{16C_{I}} \right)^{2} - f_{M} \Leftrightarrow q_{\text{max}} \frac{4 \left( C_{I} - v_{I} \right)^{2} - \left( C_{I} - 2v_{M} - v_{I} \right)^{2}}{16C_{I} \left( f_{I} - f_{M} \right)} > 0 \Leftrightarrow q_{\text{max}} \frac{\left( 3C_{I} - 3v_{I} - 2v_{M} \right) \left( C_{I} + 2v_{M} - v_{I} \right)}{16C_{I} \left( f_{I} - f_{M} \right)} > 0.
\]
We can assume that $f_I > f_M$, $C_I + 2v_M > v_I$, therefore Microsoft’s profit is greater than Intel’s if and only if

$$v_M < \frac{3(C_I - v_I)}{2},$$

and this condition is executed in practice.

The competitive interactions between Windows and Linux, Intel and AMD, Microsoft Office and OpenOffice will be discussed, and the mechanism of the conflict when Intel sets prices too high and supports Linux team, the major competitor of Microsoft, while Microsoft releases new versions too late and backs AMD, Intel’s main competitor.

The differences between this model and a model when there are just two vendors of complementary products (Intel and Microsoft) are discussed as well.

REFERENCES


