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On Strategic Enabling of Product Piracy in the Market for Video Games*

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Abstract

In this paper, we consider the market for video games, where some firms are active in both, the market for video games hardware and software. It is puzzling that hardware can be easily made compatible with duplicated (i.e. pirated) software. We ask, whether there exist strategic reasons explaining this puzzle. Firms may, for example, enable software piracy in order to increase their market shares in the hardware market. This will indeed be true, if hardware prices are fixed and the market is completely covered. With endogenous prices, however, price reactions to enabling of product piracy will offset the increase in market shares and copy protection will be set at the highest possible level. If, on the other hand, the market is only partially covered, copy protection will be strategically reduced. In doing so, hardware firms shift reservation prices from the software to the more important hardware market.

Key words: Video Games Market, Product Piracy, Fundamental Transformation

JEL classification: D21, L13, L86

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1 Introduction

The market for video games is a particularly interesting one to analyze, for it possesses an almost unique combination of characteristics. The most remarkable features are the following: (*i*) There are only a few firms (Sony, Microsoft, Nintendo, Sega) active in the market for video games consoles (the hardware needed to play video games). These firms additionally produce video games (or software) for their respective consoles. Moreover, there are other firms specializing in software production, i.e. firms that are active in the software, but not in the hardware market. (*ii*) Software produced for a certain video games console is incompatible with the consoles of other producers. Thus, there is some kind of fundamental transformation in the video games market.[1] At a first stage, consumers decide on whether or not to buy a video games console and, in the former case, on whose console to purchase. At this stage, all products are available for consumers. At a second stage, hardware has been purchased or not. Customers who have bought the video games console of a certain producer are then forced to also buy games compatible with this console. In other words, they are no longer able (or it is not worthwhile for them) to purchase software being only compatible with the console of a different producer.[2] (*iii*) Software producers are harmed by

[1] The notion "fundamental transformation" was introduced by Williamson (1985) into the theory of the firm. It describes the change from perfect market competition to a bilateral monopoly due to specific investments.

[2] An exception are naturally customers who have purchased more than one video games console. These customers are likely to form a small minority. Hence, for the majority of customers, the above reasoning should apply.

unauthorized copying of video games. Video games are presently stored on DVDs so that it is relatively easy to produce a copy of a video game. Interestingly, the use of copied software on a video games system usually requires a modification of the respective video games console. For instance, in order to use duplicated software on the European version of Sony's Playstations, it is necessary to install a so called Mod-Chip. The original aim of this Chip is to make the Playstation compatible with imported software from the US and Japan. A Mod-Chip can therefore be legally installed in every video games shop.

As producers of video games consoles are also active in the market for software, it seems puzzling that it is so easy to use copied software on a video games system. Copying of software is likely to decrease profits from software sale so why don't hardware producers undertake greater effort to make duplicated software incompatible with their hardware? Naturally, there might be technological reasons that explain part of the puzzle. Yet, this does not seem to be the whole story. In our view, there might also be strategic reasons. A hardware producing firm may, for example, enable unauthorized copying in order to increase the demand for its console. If a consumer anticipates that he is able to use duplicated games on a video games console, he might be more willing to purchase the latter. Lower profits on the software market may then be outweighed by an increase in profits from sale of hardware.

In this paper, we develop a model that analyzes, whether or not the intuition behind the previous reasoning is true. We consider two firms that are producing hardware and software for the video games market. The firms are the only hardware producers, but compete in their respective software market with other firms. The products of the single firms are supposed to be differentiated so that firms achieve positive profits from product sale. In this context, we follow the modeling approaches by Hotelling (1929) and Salop (1979), where consumers' tastes for the single products differ. Two main results will be derived: If market covering is complete, that is, if all consumers in the video games market are served and if hardware prices are fixed, enabling of product piracy will indeed increase market shares of the hardware producing firms. With endogenous prices, however, enabling customers to use copied software is countered by a hardware price reduction of the other hardware producer, which completely offsets the increase in market shares. Thus, enabling of product piracy only has an adverse effect on profits from software sale. Hardware firms hence choose the highest possible copy protection. The result will be totally different, if market covering is incomplete. In this case, enabling of product piracy shifts reservation prices from the software to the hardware market. Consumers are willing to pay a certain amount for a package of hardware and software. If they are able to use duplicated software in combination with hardware, they are willing to pay higher prices for the latter. As the hardware market is the more important one for hardware producers, they gain from such a shift in reservation prices. As a result, it pays out to set copy protection at the lowest possible value.

The paper is organized as follows: The next section briefly presents and discusses related literature. In section 3, the main model is introduced. Sections 4 and 5 solve the model for the case of complete market covering (section 4) and partial market covering (section 5). Finally, section 6 concludes.

2 Related Literature

There already exists a number of papers dealing with unauthorized copying of products.[3] This literature can be roughly divided into three categories. A first strand of literature (see e.g. Hurt & Schuchman (1966), Novos & Waldman (1984), Johnson (1985), Belleflamme (2003) or Burton et al. (2005)) recognizes that higher product piracy usually leads to lower profits of the firms, whose products are duplicated. This decrease in profits may yield lower (ex ante) incentives for firms to invest in technology, for piracy of the products reduces the gains from these investments.

The papers of Liebowitz (1985), Besen (1986), Besen & Kirby (1989), Bakos et al. (1999) and Varian (2000) argue that book or video producing firms may indirectly appropriate revenues from users who are not original purchasers. As, in these markets, libraries and video stores mostly act as a starting point of copying activities, firms indirectly appropriate revenues by demanding higher prices from these. As a consequence, firm profits in these industries may increase due to copying.

Finally, there is some literature (see, for example, Connor & Rumelt (1991), Takeyama (1994), Shy & Thisse (1999), Gayer & Shy (2003) or Peitz (2004)) analyzing the role of product piracy in the presence of network effects.

[3] For a survey see Peitz & Waelbroeck (2003).

Their main reasoning is the following: If the value of a certain product increases in the number of (legal and illegal) users, product piracy might be useful, for it leads to a higher dispersion of the product and, therefore, to an increase in product value. This increase in product value might yield higher profits so that firms might benefit from product piracy.

Two remarks are necessary: First, note that previous work has not considered the market for video games. In other markets, where product piracy is an issue, the results to be derived in this paper do not apply. This is either because hardware producing firms are not active in the software market (e.g. software produced for personal computers) or because software is also compatible with hardware of different producers (e.g. Music-CDs and Film-DVDs). Second, indirect appropriability and network effects may also play a role in the video games market. Yet, we believe that the strategic effects we concentrate on are of major importance in this market. In order to focus on these effects, we abstract from indirect appropriability and network effects considerations.

3 The model

Consider a situation with four firms (indexed by $i = 1, ..., 4$). Firms 1 and 2 are active in both, the market for video games hardware and software. Firms 3 and 4, on the other hand, are only active in the software market. Let k_1 (k_2) denote the price firm 1 (firm 2) demands for its hardware, while p_i stands for the respective software price. The software produced by firms 1 and 4 is supposed to be only usable on firm 1's hardware. Similarly, firms 2 and 3 produce software that can only be used in combination with firm 2's hardware. For simplicity and with only little loss of generality, production of both, software and hardware, occurs at zero cost. Consumers attach no value to hardware per se, but they value software. In this context, consumers are supposed to differ in tastes for the respective firms' products. Each firm produces a different video game and each video game is preferred by some consumers. To capture this formally, we follow the modeling approach by Salop (1979) and assume that consumers are uniformly distributed on a circle with a perimeter equal to 1, with total consumer mass normalized to 1. The four firms are located on this circle as shown in Figure 1.[4] The distance between firms 1 and 4 (and 2 and 3) is $b > 0$, while distance between firms 1 and 2 (and 3 and 4) is $0.5 - b$. We take the firms' locations as exogenously given. The value a consumer attaches to a video game is given by $v - td^2$. v denotes the value a consumer attaches to a product that exactly meets his taste, d is the distance[5] between the consumer's and the firm's location measured along the circle and t is a factor indicating how strongly product value decreases with distance from the firm. The assumption that valuation depends on quadratic distance is introduced to avoid problems with equilibrium existence.[6] Each consumer underlies some time constraint. This

[4]Note that the results to be derived in this paper will not change, if we exchange the locations of firms 1 and 4 and/or firms 2 and 3.

[5]Note that "distance" should not be taken literally. It acts as a metaphor, indicating, how much a firm's product differs from the consumer's most preferred product.

[6]See, for example, D'Aspremont et al. (1979) or Economides (1986). In a related model, it was respectively shown that, when distance enters in a different way into valua-

means that he only has enough time to play one single video game. Thus, if a customer has acquired some game, he will never buy a second one.

Insert Figure 1 here.

It is assumed that consumers firstly decide on their hardware purchases. Thereafter, sale of software occurs. As mentioned before, purchase of hardware leads to some kind of fundamental transformation: Before a consumer buys hardware, he may choose between four different software games. Thereafter, he has only two different products available, as the remaining two games are incompatible with his hardware. Similarly, in the hardware market, firms compete for all consumers, while, in the software market, competition is restricted to the consumers who bought appropriate hardware. We assume that no long-term contract is feasible. That is, hardware firms cannot offer a contract specifying both, purchase of hardware and a certain software at a given price. In other words, bundling of hardware and software is supposed to be impossible. This assumption could reflect the fact that, in practice, customers often purchase a video games console at a point in time, where some games are already available, but many others are not yet produced.

In the software market, firms are threatened by product piracy. We model this by assuming that, with probability q_1 (q_2), a consumer may receive costless copies of all games compatible with the hardware of firm 1 (2). As a consumer receives no extra utility from possessing a second game, he will,

tion, the firms' demand functions may be discontinuous and their profit functions may be discontinuous and non-concave. Therefore, no pure-strategy price equilibrium may exist.

in case copies compatible with the hardware are available, always copy his most preferred game and be indifferent between receiving a copy of the other game or not. q_1 and q_2 are supposed to be decision variables of the hardware producing firms. Each firm can design its hardware in a way that enables more or less copying. Let $q_1, q_2 \in [\check{q}, \hat{q}]$, with $0 < \check{q} < \hat{q} < 1$. The restriction $q_1, q_2 \in [\check{q}, \hat{q}]$ indicates that the probability of copying also depends on actions of outstanding parties that cannot be influenced by hardware producers. To focus on the strategic effects of product piracy, increasing q_1 or q_2 is assumed to be at no cost for the firms. Further, the parameters q_1 and q_2 can be observed by all parties. That is, each firm and each consumer knows the respective parameter choices.

This approach to introduce copying into the model is admittedly a very simplified one. There are two justifying reasons. First, the important effect of copying in this model is that a consumer's expected cost for acquisition of software declines. This effect, however, is also present in more sophisticated models of copying as e.g. Novos & Waldman (1984) or Connor & Rumelt (1991). Second, the model will simply be no longer tractable, if we model copying in a more complex way.

The timing of the model is as follows: At date 1, the hardware producers decide on q_1 and q_2, while, thereafter, they determine the hardware prices. The two firms act simultaneously, respectively, i.e., no firm has a first-mover advantage. At date 3, consumers decide on their hardware purchases. The software producers determine the software prices at date 4. At date 5, nature decides on whether copies of the games become available. Finally, at date

6, consumers decide on whether or not to buy software, and, in the former case, on whose software to buy. We combine dates 1 to 3 to a stage 1, where the hardware market is considered, and dates 4 to 6 to a stage 2, which deals with choices associated with the software market.

4 Complete market covering

We begin by considering the case, where, in equilibrium, each consumer decides to buy hardware and software (if copies are unavailable). That is, the market is completely covered. This will be the case, if v is sufficiently large compared to t. We work backwards and start at stage 2 of the model, i.e. we consider the software market. Note that costs for hardware acquisition are sunk and, thus, do not affect decisions at this stage. At dates 4 to 6, we usually consider two independent software markets. The first (second) consists of those customers who bought firm 1(2)'s hardware. In this context, we assume that all consumers between firms 1 and 4 (2 and 3) have acquired hardware from firm 1 (2)[7] so that hardware firms have factually been in competition for consumers between firms 1 and 2 and between firms 4 and 3. Let a denote the distance of the indifferent hardware buyer between firms 1 and 2 from firm 1's location. Then, the size of first software market is $b+2a$, whereas the size of the second market is $1-b-2a$. It is sufficient to analyze firm and consumer behavior on the first software market. The solution for the second market is analogous. As noted before, consumers differ in their

[7] This is, in equilibrium, indeed true, as will be shown, when we turn to stage 1 of the model.

valuations for the two firms' products, i.e. we are in a setting with product differentiation. Customers who bought the hardware of firm 1 and, hence, purchase software from either firm 1 or firm 4 are, as shown in Figure 2, uniformly distributed on a line segment of length $b + 2a$.[8] Firm 1's distance from the left end equals firm 4's distance from the right end and is given by a.

Insert Figure 2 here.

Denote by z a consumer's distance from the left end of the line segment. Such a consumer has net utility $u_{1s} = v - p_1 - t\left(z - a\right)^2$, if buying software from firm 1 and $u_{4s} = v - p_4 - t\left(z - b - a\right)^2$, if buying from firm 4. Hence, for the indifferent consumer the following condition must hold

$$v - p_1 - t\left(z - a\right)^2 = v - p_4 - t\left(z - b - a\right)^2 \Longleftrightarrow z = \frac{1}{2bt}\left(p_4 - p_1 + bt\left(2a + b\right)\right) \tag{1}$$

Thus, z denotes the relative amount of consumers (of population size 1) who want to acquire software from firm 1. Each consumer copies his preferred product with probability q_1. As a result, the two firms' second-stage profits are given by

$$\pi_{12} = p_1 \frac{1}{2bt}\left(p_4 - p_1 + bt\left(2a + b\right)\right)\left(1 - q_1\right) \tag{2}$$

$$\pi_{42} = p_4 \frac{1}{2bt}\left(p_1 - p_4 + bt\left(2a + b\right)\right)\left(1 - q_1\right) \tag{3}$$

[8] Competition in the software market is therefore analogous to Hotelling's model (1929) of the "linear city".

Maximizing these profits leads to a symmetric solution, i.e., both firms choose the same prize $p_1 = p_4 =: p = bt\,(2a+b)$.[9] Inserting this price into (2) and (3), respectively, yields the optimal profits, which are given by $\pi_{12} = \pi_{42} = \frac{t}{2}\,(1-q_1)\,b\,(2a+b)^2$. One can easily see that these profits are decreasing in q_1. This is very intuitive. The higher the probability of copying, the smaller is the number of customers who actually pay for a product and the smaller are profits. Further, we get the well-known results that profits are higher, the stronger product value decreases with distance and the bigger the market. Let us now turn to stage 1 of the model.

At this stage, each consumer has to decide on whether or not to buy hardware. In the former case, the consumer additionally has to decide on whose hardware to buy. Divide the circle horizontally into two halves and consider a consumer being located in the lower half. Such a consumer will, at the model's second stage, buy software from either firm 1 or firm 2.[10] Let y denote his distance from the left end of the lower half of the circle. His net utilities, if buying from firm 1 (2), are then given by $u_{1h} = v - k_1 - (1-q_1)\,bt\,(2a+b) - t\,(y-0.5b)^2$ $\left(u_{2h} = v - k_2 - (1-q_2)\,bt\,(1-b-2a) - t\,(0.5-0.5b-y)^2\right)$. The net utility consists of gross utility $\left(v - t\,(y-0.5b)^2 \text{ or } v - t\,(0.5-0.5b-y)^2\right)$ from playing the video game minus expected costs for hardware (k_1 or k_2) and software ($(1-q_1)\,bt\,(2a+b)$ or $(1-q_2)\,bt\,(1-b-2a)$) acquisition. For the indifferent consumer, u_{1h} must equal u_{2h}. We thus have the following

[9] Notice that here, as well as in all maximization problems that follow, the second-order conditions are met.

[10] This is a consequence of the second-stage solution's symmetry.

condition:[11]

$$a=\frac{t-4b^2t+4\left(k_2-k_1\right)-4btq_2\left(1-b\right)+4b^2tq_1}{4t+8bt-8bt\left(q_1+q_2\right)} \tag{4}$$

As the demand for firm 1's (firm 2's) hardware equals $b+2a$ $(1-b-2a)$, the two firms' overall profits (that is, the sum of the profits from hardware and software sale) are given by

$$\begin{aligned}
\pi_1 &= k_1\left(b+\frac{t-4b^2t+4\left(k_2-k_1\right)-4btq_2\left(1-b\right)+4b^2tq_1}{2t+4bt-4bt\left(q_1+q_2\right)}\right) \qquad (5)\\
&\quad +\frac{\left(1-q_1\right)bt}{2}\left(b+\frac{t-4b^2t+4\left(k_2-k_1\right)-4btq_2\left(1-b\right)+4b^2tq_1}{2t+4bt-4bt\left(q_1+q_2\right)}\right)^2\\
\pi_2 &= k_2\left(1-b-\frac{t-4b^2t+4\left(k_2-k_1\right)-4btq_2\left(1-b\right)+4b^2tq_1}{2t+4bt-4bt\left(q_1+q_2\right)}\right) \qquad (6)\\
&\quad +\frac{t}{2}\left(1-q_2\right)\left(1-b-\frac{t-4b^2t+4\left(k_2-k_1\right)-4btq_2\left(1-b\right)+4b^2tq_1}{2t+4bt-4bt\left(q_1+q_2\right)}\right)^2
\end{aligned}$$

Before turning to a derivation of the optimal hardware prices, it is worthwhile to look at the effects a change in q_1 (q_2) has on the profit of firm 1 (2). For fixed hardware prices, an increase in q_1 affects firm 1's profit in two ways. On the one hand, it affects the demand for the firm's hardware and, indirectly, for its software. As $\frac{\partial a}{\partial q_1}>0$,[12] higher copy protection leads to lower demand. Customers realize that their expected costs from software acquisition increase and so change to the competitor. On the other hand, higher copy protection leads to higher profit from software sale since more customers buy software instead of copying it.

Let us now analyze, whether or not the effects will change, if we endogenize hardware prices. Both firms determine their hardware price such that

[11] Note that, for the indifferent consumer, $y=0.5b+a$.

[12] A proof of this statement is placed in the Appendix.

the overall profit is maximized. Solving the maximization-problems leads to the subsequent first-order conditions:

$$\begin{aligned} 0 &= t + 2bt + 4k_2 - 8k_1 - 4btq_2 \\ &\quad - \frac{4(1-q_1)\,bt\,(t + 2bt + 4k_2 - 4k_1 - 4btq_2)}{2t + 4bt - 4bt\,(q_1 + q_2)} \end{aligned} \tag{7}$$

$$\begin{aligned} 0 &= t + 2bt + 4k_1 - 8k_2 - 4btq_1 \\ &\quad - \frac{4(1-q_2)\,bt\,(t + 2bt + 4k_1 - 4k_2 - 4btq_1)}{2t + 4bt - 4bt\,(q_1 + q_2)} \end{aligned} \tag{8}$$

Solving these first-order conditions simultaneously, one can show that the optimal hardware prices satisfy $k_1 = 0.5t\,(0.5 - bq_2)$ and $k_2 = 0.5t\,(0.5 - bq_1)$. The optimal profits can then be derived by inserting the hardware prices into the profit functions. Profits are given by $\pi_1 = 0.125t\,(1 + b - 2bq_2 - bq_1)$ and $\pi_2 = 0.125t\,(1 + b - 2bq_1 - bq_2)$. Considering these profits, it is straightforward to derive the following proposition:

Proposition 1 *Both firms choose q_i at its lowest possible value, i.e. $q_1 = q_2 = \check{q}$.*

We see that, with endogenous prices, firms are not interested in tolerating product piracy. The reason for this result will be obvious, if we consider hardware market sizes with endogenous prices. These are $b+2a = 1-b-2a = 0.5$, which is independent of q_1 and q_2. In words, with endogenous prices, firms are no longer able to win market shares by allowing duplication of their products. A decrease in copy protection of one firm is countered by a decrease in price of the other firm's product, which exactly offsets the increase in market share. As lower copy protection still leads to lower profits from software sale, firms determine copy protection at its highest possible value.

5 Partial market covering

In this section we check, whether the model results will change, if some consumers decide not to purchase a product at all. That is, we depart from the assumption of complete market covering and turn to a model of partial market covering. Partial market covering will take place, if t is rather large compared to v. Let us first determine the identities of consumers who forego product acquisition. This is a very easy task. If some consumers decide not to purchase a product at all, these will be the consumers, whose tastes coincide least with the video games offered by the single firms. Put differently, consumers who decide not to purchase any product at all are those, whose distances to the nearest software firm are highest (at least, if prices are same for all consoles and video games, respectively, as will be the case in equilibrium). We then must differentiate between three possible cases: In the first case, $|(0.5-b)-b|$ is rather low. In words, distances between neighboring firms do not differ significantly. Consequently, there should be non-purchasing consumers between all pairs of neighboring firms. In the second case, b is relatively high (and, hence, $0.5-b$ relatively low). That is, the distance between firms 1 and 2 (and between firms 3 and 4) is rather low. Here, only some consumers between firms 1 and 4 and between firms 2 and 3 forego product purchase. Finally, in the third case, b is rather low and $0.5-b$ high. Thus, distance between firms 1 and 4 (and between firms 2 and 3) is low so that non-purchasing consumers are only located between firms 1 and 2 and between firms 3 and 4. It turns out that the second and the third case are hardly tractable. We therefore restrict our formal analysis to the first case and offer an informal discussion of the remaining ones.

Let us start with the second stage and the software market.[13] We provide a detailed analysis of the market for software compatible with firm 1's hardware. The analysis of the second software market is completely analogous. It is important to note that the software market now consists of two disconnected sets of consumers, one surrounding firm 1 and another surrounding firm 4. There are consumers being located between these firms who decided not to purchase hardware at all. Denote the set of consumers surrounding a firm as the firm's neighborhood. It is easy to see that $\frac{t}{v}$ must be so large that each firm acts as a local monopolist in its neighborhood.[14] If this were not the case, there must be some consumer being indifferent between buying a video game from firm 1 or firm 4. In equilibrium, this consumer must lie within one of the neighborhoods, as, otherwise, the firms would deviate from their initial strategy by increasing prices without suffering a loss in customers. But then, all non-purchasing consumers had a higher net value from purchasing software than the indifferent consumer contradicting the assumption that the latter found it worthwhile to acquire a video games console, while the former did not. To summarize, each software producer is, in its neighborhood, in a monopoly position and determines the price for its software without taking the other firm's software price into account. Hence, both firms face the same maximization problem so that the respective software prices should be same,

[13] Note that money spent on hardware is again sunk at this stage.

[14] Notice that, if t is relatively high compared to v, a firm will simply be unable (or unwilling) to alienate consumers from the other firm's neighborhood, as these consumers attach a much higher value to the latter firm's product.

too. This implies that the two firms' neighborhoods are of equal size, for a neighborhood's size is determined by the hardware price, the software price and the copying probability, and all these variables are equal for both firms. Let the size of each firm's neighborhood be given by $2f$. The neighborhoods are symmetric with f consumers being located on each side of a firm.

When deriving the optimal software price of a firm, two solutions are imaginable: In the first solution, each neighborhood is so large that a monopoly solution is feasible, that is, each firm can set the price for its product optimally, without taking the market size into account. Formally, firm i then maximizes

$$\pi_{i2} = (1 - q_1)\, 2p\sqrt{\frac{v - p}{t}} \tag{9}$$

In a monopoly solution, consumers satisfying $p + td^2 = v \Longleftrightarrow d = \sqrt{\frac{v-p}{t}}$ will be indifferent between buying and not buying the software, if no copy is available. Hence, the expected software demand is $(1 - q_1)\, 2\sqrt{\frac{v-p}{t}}$, leading to the above profit formula. Maximizing profit with respect to price, yields the following monopoly solution:

$$p_m = \frac{2v}{3}, d_m = \sqrt{\frac{v}{3t}}, \pi_m = (1 - q_1)\, \frac{4v}{3}\sqrt{\frac{v}{3t}} \tag{10}$$

This solution, however, will only be feasible, if the consumer satisfying $d = \sqrt{\frac{v}{3t}}$ has actually acquired a video games console and, so, does not belong to the set of non-purchasing consumers. If this is not the case, the farthest customer in the firm's neighborhood will achieve a rent, i.e. his valuation for the video game exceeds the monopoly price. It is then optimal to raise the price such that the farthest customer becomes indifferent between buying the firm's software and not buying any software at all. In this way, the firm is paid higher prices for its product and does not suffer from a loss in customers. Formally, the price becomes $p = v - tf^2$ and the corresponding profit $\pi = (1 - q_1) 2f (v - tf^2)$. To summarize, depending on how much customers have acquired hardware, that is, depending on the software market size, the firms set the price equal to $p = \max \left\{ \frac{2v}{3}; v - tf^2 \right\}$.

Turn now to the first stage of the model, where the hardware market is dealt with. As, in the considered case, some consumers being located in the segment between firms 1 and 2 decide not to purchase any product at all, each firm is again in a local monopoly position.[15] The two firms thus face the same maximization problems, and we explicitly derive the solution only for firm 1. Let us start by assuming that some hardware buyers are not going to purchase software at the equilibrium price. These customers buy hardware, while hoping to get a costless copy of their preferred game. From the discussion of the software market we know that this can only happen, if software firms are able to achieve the monopoly solution, i.e. if $f > d_m$, as otherwise even the farthest customer in a firm's neighborhood is willing to pay for software. Consider, under this assumption, the demand for firm 1's hardware. The consumer being indifferent between purchasing this hardware and not purchasing any product at all must satisfy the following constraint:

$$k_1 = q_1 \left(v - td^2 \right) \tag{11}$$

As mentioned before, there are some customers that, although having acquired a video games console, do not purchase a corresponding game so that

[15] The argumentation behind this result is the same as in the software market.

they don't incur software acquisition costs, but realize $v - td^2$ only with probability q_1. Solving the above condition for d yields $d = \sqrt{\frac{q_1 v - k_1}{q_1 t}}$. It is then straightforward to derive firm 1's overall profit as a function of q_1 and k_1, namely

$$\pi_1 = 4k_1 \sqrt{\frac{q_1 v - k_1}{q_1 t}} + (1 - q_1) \frac{4v}{3} \sqrt{\frac{v}{3t}} \tag{12}$$

Profit from software sale is independent of k_1, as, at the second stage, firms realize their monopoly profits. One can easily show that maximization of π_1 leads to $k_1 = \frac{2q_1 v}{3}$ and $d = \sqrt{\frac{v}{3t}}$. Note that d is equal to d_m. This, however, contradicts the assumption that some customers purchase hardware, but no original software. Thus, in equilibrium, each customer buying hardware must also be willing to buy original software, if copies are not available. We therefore have $p = v - tf^2$, i.e. we are in the second proposed scenario. We turn to this scenario next.

Suppose now that all hardware buyers will also buy original software, if copies are unavailable. In this case, the equivalent to condition (11) is[16]

$$k_1 + (1 - q_1) \left(v - tf^2\right) + tf^2 = v \Longleftrightarrow f = \sqrt{\frac{q_1 v - k_1}{q_1 t}} \tag{13}$$

If, here, a copy is unavailable for a consumer, he always decides to purchase original software. Thus, expected costs from software acquisition are $(1 - q_1)(v - tf^2)$ leading to the above expression for the indifferent customer. Analogously to the preceding analysis, one can derive firm 1's overall profit,

[16]Note that we get the same condition for the indifferent consumer as in the first proposed scenario.

which equals

$$\pi_1 = 4k_1\sqrt{\frac{q_1 v - k_1}{q_1 t}} + (1-q_1)\,2\sqrt{\frac{q_1 v - k_1}{q_1 t}}\frac{k_1}{q_1} \tag{14}$$

Maximizing this profit leads to $k_1 = \frac{2q_1 v}{3}$ as the optimal hardware price. Reinserting this price into the profit function, we get a reduced form of firm 1's profit, which is given by $\pi_1 = \frac{8q_1 v}{3}\sqrt{\frac{v}{3t}} + (1-q_1)\sqrt{\frac{v}{3t}}\frac{4v}{3} = \sqrt{\frac{v}{3t}}\frac{4v}{3}(1+q_1)$. From the last expression, it is obvious that overall profit is strictly increasing in q_1. We are therefore able to derive the following proposition:

Proposition 2 *Firm 1 sets $q_1 = \hat{q}$, i.e. it chooses the lowest possible level of copy protection.*

Proposition 2 offers a very interesting result. Contrary to the case of full market covering, the firms are now interested in strategically enabling product piracy. Why is this the case? Note first that, under the optimal price, we have $f = \sqrt{\frac{v}{3t}}$, i.e. f is independent of q_1.[17] Hence, firms do not enable product piracy in order to attract more customers. Enabling of unauthorized copying serves a different purpose here that is connected with the fundamental transformation described before. Note that, in the considered model, firms are local monopolists, both in the hardware as well as in the software market. Yet, the number of customers a firm serves is different

[17]Notice that $f = \sqrt{\frac{v}{3t}}$ implies $p = \frac{2v}{3}$ as the optimal price for software. Hence, the software markets are just big enough to enable the monopoly solution. In fact, f is chosen such that we are at the interface of the monopoly solution and the case, where the farthest customer will be indifferent between buying and not buying software, if copies are unavailable.

in each market. Firm 1 provides $4f$ customers with hardware, but only $2f$ customers with software. Thus, the hardware market is more important for firm 1 than the market for software. If firm 1 makes it relatively easy for its hardware purchasers to copy the compatible video games, profits from software sale will clearly decrease, but the willingness to pay for hardware will increase. It is this last effect that makes it worthwhile for hardware producers to enable product piracy. In this way, reservation prices can be shifted from the rather unimportant software market to the more essential market for video games hardware.

Before finishing this section, we informally comment on the remaining two cases mentioned at the beginning of this section. In the second case, the hardware market is characterized by competition, whereas, in the software market, firms act as local monopolists. Considering this model structure, it may be that the results from Proposition 2 do no longer hold. As firm 1 enjoys a monopoly position only in the software market, the relative importance of the hardware market decreases. Further, enabling of product piracy may again be countered by price reactions of the competing hardware producer. There are thus countervailing effects so that it is unclear, whether or not reservation prices should be shifted from the software to the hardware market. In the third case, the situation is completely different. There, firms face competition in the software market, but act as local monopolists in the hardware market. Hence, for firms 1 and 2 the hardware market is certainly more important than the market for software. Further, prices are set independently in the hardware market so that the results from Proposition 2 should hold in this scenario, too.

6 Conclusion

In this paper, we dealt with the issue of strategic enabling of product piracy in the market for video games. We analyzed, under what conditions product piracy is enabled by hardware producers and when it is not. The main result was that enabling of product piracy is a device to shift reservation prices from the software market to the more important market for video games hardware.

A caveat is necessary at this point. It is usually the case that consumers will be more willing to purchase a certain video games console, if many games for this console are available. If this is the case, hardware producers might additionally be in competition for services of software producing firms. If, then, a hardware producer enables product piracy, while the other does not, software firms may decide to solely produce for the latter (especially, when producing for a second firm entails high costs) so that enabling of product piracy could have an unmentioned negative effect that may offset the positive one.

Finally, it is worth emphasizing that there exist further markets to which the model nicely applies. Consider e.g. the market for sporting events. An organizer of such an event realizes profits through two channels, namely through ticket sale and catering. In sports arenas, some snack bars or restaurants are usually run by the organizer, while others are run by private people.

A consumer who expects to eat and drink something, while attending the sporting event, will be less willing to pay high ticket prices, if food is rather expensive. Similarly to the reasoning above, the organizer of the sporting event might then allow customers to bring their own food to the event to increase reservation prices for tickets. Lower profits from catering would be outweighed by higher profits from ticket sale.

Appendix

In this Appendix, it is shown that $a = \frac{t-4b^2t+4(k_2-k_1)-4btq_2(1-b)+4b^2tq_1}{4t+8bt-8bt(q_1+q_2)}$ is increasing in q_1. Differentiating a with respect to q_1 yields:

$$\frac{\partial a}{\partial q_1} > 0 \iff b\left(4t + 8bt - 8bt\left(q_1 + q_2\right)\right) + \left(t - 4b^2t + 4\left(k_2 - k_1\right) - 4btq_2\left(1 - b\right) + 4b^2tq_1\right)2 > 0$$

This inequality can be simplified to

$$4\left(k_2 - k_1\right) > 4btq_2 - 2bt - t$$

Note that $a \geq 0$. Thus, $t - 4b^2t + 4\left(k_2 - k_1\right) - 4btq_2\left(1 - b\right) + 4b^2tq_1 \geq 0$, as the denominator in a is strictly positive. Transforming the last condition gives $4\left(k_2 - k_1\right) \geq 4btq_2\left(1 - b\right) - 4b^2tq_1 + 4b^2t - t$. Hence, $\frac{\partial a}{\partial q_1} > 0$ must always hold, if $4btq_2\left(1 - b\right) - 4b^2tq_1 + 4b^2t - t > 4btq_2 - 2bt - t \iff 2bt\left(1 - q_2\right) + t\left(1 - 2bq_1\right) > 0$. This conditions always holds, as both terms in parentheses are strictly positive. Q.E.D.

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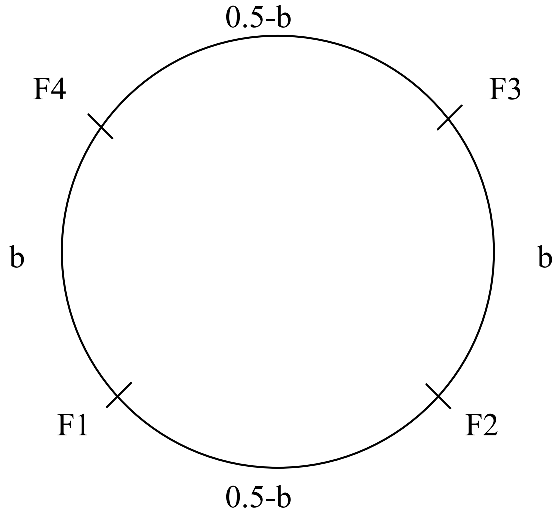

Figure 1. Locations of the four firms.

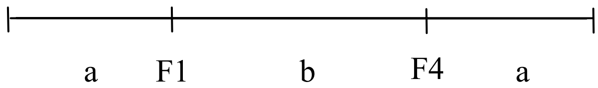

Figure 2. Locations of the two firms in the first software market.