

A note on strategic piracy in the economics of software: an explanation by learning costs

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Abstract: *We explain strategic piracy in the software industry as a result of the presence of learning costs in the context of intertemporal price discrimination. First, piracy can be a means to incite consumers to invest in human capital, which increases their propensity to pay and enables the firm to raise prices. Second, the presence of piracy induces a more efficient intertemporal price discrimination.*

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*“As the evidence indicates, a variety of information-based industries can thrive not only despite, but because of, rampant piracy”,
(Tehrani [2003])*

1 Introduction

A well known fact in the economics of information is that practices evolve slower than technologies themselves, in such a way that consumers need to learn how to use information technology capital. Furthermore and particularly in the case of the software industry, the gross benefit from using a software is two-sided. On the one hand, some value is created by the quality and potential applications of the software; increasing the possibilities provided by the software, such as multi-functionalities and specializations, make the software more valuable. On the other hand, time and effort have to be spent in learning to use it and capture effective value. Expressed differently, the market is bounded below by the level of competence of users. A direct consequence for sellers is that the *formation* of consumers becomes a crucial determinant of their market share and much investment (like interface optimization) is devoted to this issue. Consequently, sellers cope with the following trade off : either developing or not softwares to their best sophistication, which would induce a costly learning for the users.

On the demand side, stylized facts suggest that pirated softwares provide less valorization opportunities than bought ones. An institutional argument basically applies; in the world

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of firms, using a pirated software is risky as soon as the objects built with its help are commercialized or exchanged. That is, the possibilities provided by a pirated software are often limited to internal use. Then, there is often a sharp difference in the utilities derived from bought versus pirated software, whatever the quality of the copy² (in the numerical area, copies are often exact replications of originals).

Another major empirical feature of the markets of sophisticated softwares is that consumers are strongly heterogenous in terms of possible valorization of the product. To fix ideas, let us give the example of the software *Photoshop* (imaging treatment) developed by *Adobe*. Users can be roughly divided in two categories: professionals of graphical treatment (publicity agencies, editors, ...) with high valuation for the good on the one hand, a far more heterogenous population in terms of valuation (non professional or semi-professional webmasters, firms not specialized in the domain) on the other hand. In the former category piracy is weak, in the latter piracy is important.

The existence of heterogenous consumers suggests an analysis of price discrimination. Furthermore, the learning aspect requires an intertemporal study. We present a model, inspired from Takeyama (1997), integrating these facts, and we examine the implications of piracy³. In the proposed model, a monopoly sells a durable and specialized software for two periods and chooses to raise or not a non costly and efficient protection device at the beginning of the first period. Consumers are divided in high-valuation and low-valuation types. The first period consumers (buyers and eventually pirates) incur a fixed learning cost. At period two, those even consumers do not bear the learning cost any more, whereas the part of the demand who did nothing in period one incurs the learning cost if buying or pirating. We mainly focus on the equilibria with intertemporal price discrimination. That is, the firm sells the product to high-valuation consumers in the first period and

²Part of the existing literature on piracy -see Peitz and Waelbroeck (2003) for a recent survey- explicitly introduces qualities and the results stem from the fact that the copy is a deteriorated version of the original. Reasoning on utilities provides a means of keeping true the main results of that literature even in the case the copy and the original are of the same quality.

³The 2002 annual report of the Business Software Alliance on piracy shows that “software piracy continues to pose challenges for the software industry”. In particular, the 2001 piracy rate (in the world) is 40 percent and the loss for manufacturers amounts to 10.97 billions dollars, especially in North America, Western Europe and Asia/Pacific. Concerning the USA, this concerns 25 percent of all licenses and the loss is about 1.81 billions dollars. Of course, this data collection must be qualified. First, the retail value of the amount of software to be pirated is quite different from the actual loss, given that many people who pirate software would not have purchased it at retail price if piracy was not an option. Second, the literature on strategic piracy points out reasons for firms to take some advantage of piracy.

low-valuation consumers in the second period. In that context, it can be rational for low-valuation consumers to pirate the product in period one and buy it in period two (since the valorization of the bought product is higher than pirated one). Then, facing the need of forming users to their softwares, firms can strategically implement low protection devices, as instrumenting piracy in the goal of forming consumers. To support this intuition, we put ahead two mechanisms by which the presence of piracy can increase the firm's profit in a context of learning costs.

We show that the strategy consisting in discriminating and establishing no protection is an equilibrium of the game for intermediate learning costs. The two basic and complementary reasons are that (i) in the presence of piracy the second period price does not incorporate the learning cost, which can lead the firm to raise this price for sufficiently high learning costs, and (ii) this allows the firm to extract a better surplus from price discrimination. The latter point stems from an intertemporal argument: in this equilibrium, the first period price is constrained: high type consumers must not wait and buy in period two, which bounds above the first period price. Thus, when the second period price increases, the constraint on the first period price is relaxed, which allows the firm to raise the first period price.

To sum up, a condition of emergence of a market for sophisticated softwares is the mutual adjustment of the cost of software development and the learning cost of the users. Piracy can be a means to incite consumers to invest in human capital, which increases their propensity to pay and enables the firm to raise prices.

This paper is complementary to previous works. A well known argument relates the profitability of piracy to network externalities. Conner and Rumelt (1991) show that a monopolist can find a strategic opportunity as allowing for piracy in the presence of network externalities. Similar findings are in Takeyama (1994) and Slive and Bernhardt (1998). Notably, the two papers argue that piracy can be viewed as a form of price discrimination in which the manufacturer sells some of the software at a price of zero. In the presence of significant network externalities for the software, it may be profit maximizing for the software manufacturer to tolerate piracy by home consumers, most of whom have a low willingness to pay, because they contribute to the valuation of the good made by legal users. In a competitive market, Shy and Thisse (1999) show that not protecting is a possible strategic action in the presence of network externalities, in order to reduce competition (piracy induces less demand for other firms). We note that this trend of literature, linking network externalities and strategic piracy, is contradicted by Poddar (2002) who argues

that these results are strongly model specific.

Takeyama (1997) examines the consequences of the presence of piracy according to another dimension. She examines the intertemporal implications of piracy on monopoly profit in a two-period model with two types of consumers (with high- and low-valuation in the utilization of the product) but without network externalities. Therefore, she exhibits a specific source of profit loss: the monopolist, as setting up price discrimination in the first period, must propose a price that prevents first period consumers (those of high-valuation) to wait and buy in the second period.

Lastly, Banerjee (2001) and Chen and Png (2003) study the policy implications of piracy. Banerjee shows that the optimal level of tracking set up by the government is not always high, while Chen and Png show that an increase in detection can affect welfare more negatively than price cuts.

Section 2 develops the model, section 3 gives the result under the form a proposition. The proof of the proposition is given in section 4.

2 The model

We use the model of Takeyama (1997) as a benchmark model. Indeed, the author proposes a two-period model, fruitful for our purpose. Formally, the initial model is slightly modified as we add a learning cost.

The model can be described as follows. A monopolist sells a durable good for two periods. The durable good does not depreciate and its production cost is ensured by the means of a positive and constant marginal cost c . At the beginning of each period, the firm announces a unit price P_i for the period and consumers choose whether to buy, to do nothing or eventually to pirate if possible. We suppose that setting up a protection is non costly and does not depreciate the quality of the good.

There are N consumers, each living two periods and arriving at the beginning of period one on the market. In both periods the consumers have an inelastic demand for one unit of the good. Consumers are heterogenous: N^H of them are high-valuation consumers (denoted thereafter H-type consumers) and $N^L = N - N^H$ are low-valuation consumers (L-type consumers). Per-period consumption gives respective utilities of V^H and V^L if the good is bought. Furthermore, during the first period of utilization of the good, consumers bear a fixed learning cost c_l (whenever the product is used for the first time in period one or two). Like Takeyama, we assume that high-valuation consumers do not pirate and V_c^L is the utility of low type consumers if the good is pirated. The cost of pirating is denoted

as p_c . It is assumed that $V^H \geq V^L$. In this model there is no explicit mention of quality (of originals as well as of copies) and the focus is on utilities (see the introduction for a justification even if the original and the copy are of the same quality).

The actions profiles describing the available intertemporal consumers' behaviors are given in the tables 1 and 2. Table 1 sums up the possible actions and consumer surplus associated when piracy is not a possible option and table 2 describes the same when pirating is a possible option.

Period 1 action	Period 2 action	Consumer surplus
Buy	Do nothing	$V^j + \beta V^j - P_1 - c_1$
Do nothing	Buy	$\beta (V^j - P_2 - c_1)$
Do nothing	Do nothing	0

Table 1: Piracy is not possible; $i \in \{L, H\}$

Period 1 action	Period 2 action	Consumer surplus
Buy	Do nothing	$V^j + \beta V^j - P_1 - c_1$
Copy	Buy	$V_c^j - P_c - c_1 + \beta (V^j - P_2)$
Copy	Do nothing	$V_c^j (1 + \beta) - P_c - c_1$
Do nothing	Buy	$\beta (V^j - P_2 - c_1)$
Do nothing	Copy	$\beta (V_c^j - P_c - c_1)$
Do nothing	Do nothing	0

Table 2: Piracy is possible; $i \in \{L, H\}$

As the good is durable, we assume that consumers have perfect forward looking strategies. For convenience, we shall further denote the consumers' action profiles as $(X, Y)_i$, $i \in \{L, H\}$, $(X, Y) \in \{C, B, \emptyset\}$. Symbol C means copying (or equivalently pirating), symbol B means buying, symbol \emptyset means doing nothing.

3 Results

The benchmark case where piracy is not possible is presented in a first subsection. Then we introduce piracy as a possible option for consumers and we conclude that the presence of piracy can increase the firm's profit.

3.1 Copying is not a possible option

We suppose here that the firm sets up a non costly and efficient protection against piracy. The following result applies:

Result 3.1 *When copying is not an option, the discriminating situation in which H-type consumers buy the product in period one at price $P_1 = V^H + \beta V^L - c_l$ and L-type consumers buy the good in period 2 at price $P_2 = V^L - c_l$ induces the best firm's profit as soon as:*

$$c_l > \frac{V^L}{1 - \beta} - \left(\frac{V^H - V^L}{1 - \beta} \right) \left(\frac{N^H}{N^L} \right) - c$$

Proof of the result. Suppose that the monopoly discriminates in period 1, *i.e.* H-type consumers buy in period 1 and L-type consumers buy in period 2. Then the firm must prevent H-type users from waiting and buying the product in period 2. This leads to the following constraint:

$$P_1 \leq V^H + \beta P_2 - (1 - \beta)c_l$$

The best price in period 2, consisting in extracting all L-type consumer surplus, is:

$$P_2 = V^L - c_l$$

Introducing this latter price in the first inequality, the best period 1 price writes:

$$P_1 = V^H + \beta V^L - c_l$$

This induces the following discounted profit under discrimination:

$$\pi^d = (V^H + \beta V^L - c_l - c)N^H + \beta(V^L - c_l - c)N^L$$

Suppose now that the monopoly does not discriminate consumers. Then, all consumers buy in period 1 under the following price⁴:

$$P_1 = V^L + \beta V^L - c_l$$

⁴and supposing that the firm proposes a period 2 high price in such a way that it is rational for all consumers not to buy in period 2.

which induces the following equilibrium profit:

$$\pi^{nd} = (V^L + \beta V^L - c_l - c)(N^H + N^L)$$

Hence, discriminating is profitable if

$$\frac{N^H}{N^L} > \frac{V^L - (1 - \beta)(c_l + c)}{V^H - V^L}$$

Hence we are done. \square

Remarks:

(i) the greater the learning cost, the more likely this inequality to be satisfied. This results from the discount factor. Precisely, all prices are negatively impacted by the learning cost; when this cost increases, both prices and profits decrease. Since the firm takes a smaller account of the second period buyers, an equal decrease in prices is less prejudicious to the part of the profit captured from second period purchases. Hence, as second period purchases only occur under discrimination, the discriminating profit is more likely to be greater than the non discriminating profit as soon as there is an effective time preference.

(ii) under discrimination the monopoly cannot fully discriminate whereas there is complete information. This is due to the intertemporal constraint according which H-type consumers must not buy in period two.

3.2 Copying is a possible option

We suppose now that the firm does not protect its product. Hence pirating is a possible option. We recall that only L-type consumers are likely to pirate. The following proposition exhibits a situation in which discriminating is better than non discriminating in the presence of piracy.

Proposition 3.1 *When copying is an option, the discriminating situation in which H-type consumers buy in period one at price $P_1 = V^H + \beta(V^L - V_c^L) - (1 - \beta)c_l$ and L-type consumers copy illegally the product in period 1 and buy the product in period 2 at price $P_2 = V^L - V_c^L$ entails the best firm's profit as soon as the learning cost satisfies the following inequalities:*

$$c_l < \min \left[\frac{V_c^L - p_c}{1 - \beta}, V_c^L(1 + \beta) - p_c, \frac{V^H}{1 - \beta} - \left(\frac{V^L - V_c^L - p_c}{1 - \beta} \right) \left(1 + \frac{N^L}{N^H} \right) \right]$$

Proof of the proposition. Suppose that the firm discriminates in period 1 and that the optimal strategy of L-type consumers is copying in period 1 and buying in period 2. Then, one constraint is that the strategy consisting in copying in period 1 and doing nothing in period 2 is less interesting for them. This induces to the following constraint on second period price:

$$P_2 < V^L - V_c^L$$

Suppose in a first step that this is the most important constraint on P_2 . Then, integrating this value in P_1 , the profit under discrimination writes:

$$\pi^d = (V^H + \beta(V^L - V_c^L) - c_l(1 - \beta) - c)N^H + (V^L - V_c^L - c)N^L$$

In a second step, let us examine the additional conditions on the learning cost under which this outcome is an equilibrium of the game.

► Individual rationality: $(C, B)_L > (\emptyset, \emptyset)_L$

This entails $P_2 < V^L - V_c^L + \frac{V_c^L(1+\beta) - p_c - c_l}{\beta}$. This constraint is weaker than the constraint $(C, B)_L > (C, \emptyset)_L$ as soon as

$$c_l < V_c^L(1 + \beta) - p_c$$

Note that if the constraint is stronger, then P_2 is less than $V^L - V_c^L$, which induces a smaller profit (than when piracy is not an option).

► L-type consumers are pirates: $(C, B)_L > (\emptyset, B)_L$

This induces that

$$c_l < \frac{V_c^L - p_c}{1 - \beta}$$

► The profit under discrimination is greater than the profit without discrimination. Now, if the firm does not discriminate, the price P_1 is not higher than $(V^L - V_c^L)(1 + \beta) + p_c$ since the firm must prevent L-type agents from pirating rather than buying (this constraint is effective as soon as $c_l < V_c^L(1 + \beta) - p_c$). Then, the profit writes:

$$\pi^{nd} = \left[(V^L - V_c^L)(1 + \beta) + p_c - c \right] (N^H + N^L)$$

comparing the two profits, the learning cost must satisfy:

$$c_l < \frac{V^H N^H - (V^L - V_c^L - p_c)(N^H + N^L)}{(1 - \beta)N^H}$$

So we are done ■

Remarks:

(i) the constraint ensuring the presence of piracy is stronger (with respect to the learning cost) than the rationality constraint as soon as $V_c^L > \frac{p_c}{\beta}$. This is true for sufficiently small costs of piracy.

(ii) the inequalities are more likely to be satisfied when the cost of pirating p_c is sufficiently small and when the time preference β is sufficiently high for the two first side members of the min. Concerning the third member of the min, we need a sufficiently high value of β or V^H .

3.3 To protect or not

From the above result and proposition, a corollary states the conditions on the learning cost under which the firm prefers not to protect its product in order enable the existence of piracy:

Corollary 3.1 *The situation in which the firm does not set up a protection, H-type consumers buy in period one at price $P_1 = V^H + \beta(V^L - V_c^L) - (1 - \beta)c_l$ and L-type consumers copy illegally the product in period 1 and buy the product in period 2 at price $P_2 = V^L - V_c^L$ is an equilibrium of the game if the learning cost satisfies the following inequalities:*

$$\left\{ \begin{array}{l} \max \left[V_c^L, \frac{V^L N^L - (V^H - V^L) N^H}{(1 - \beta) N^L} - c \right] < c_l \\ \text{and} \\ c_l < \min \left[\frac{V_c^L - p_c}{1 - \beta}, V_c^L (1 + \beta) - p_c, \frac{V^H}{1 - \beta} - \left(\frac{V^L - V_c^L - p_c}{1 - \beta} \right) \left(1 + \frac{N^L}{N^H} \right) \right] \end{array} \right.$$

Proof of the corollary. We need a useful lemma. As said previously, the firm must prevent H-type consumers to buy in period 2, entailing that the best first period price is:

$$P_1 = V^H + \beta P_2 - (1 - \beta)c_l$$

It follows directly that

Lemma 3.1 *If the firm discriminates in period 1, its best profit increases when the second period price increases.*

Proof of the lemma. Indeed, this profit writes

$$\pi^d = (V^H + \beta P_2 - (1 - \beta)c_l - c)N^H + (P_2 - c)N^L$$

Clearly, when P_2 increases, P_1 does likewise. Moreover, demands are inelastic. \square

Hence, when P_2 increases, this allows the monopolist to raise P_1 , since H-type consumers are less incited to buy the product in period 2.

To establishing the corollary, we must add to the constraints provided in the proposition two new ones. First, as comparing the profits under discrimination in the case of

piracy and no piracy, it stems basically that the presence of piracy increases the profit of the firm as soon as $V_c^L < c_l$. The reason is that without piracy the second period price incorporates the learning cost, whereas it is no more the case if pirates exist. This enables the firm to raise P_2 which leads, following the lemma, to a better profit. Second, in the case piracy is not an option, discriminating is better than no discrimination, so we must add the constraint established in the result. \square

Remarks:

(i) let us note simple sufficient conditions for the inequalities to hold. Assume to simplify that the cost of pirating and the marginal cost are negligible. Then, the last inequality (in the case piracy is not an option, discriminating is better than no discrimination) is compatible with the inequality expressing that in the presence of piracy the profit under discrimination is greater than the profit without discrimination as soon as

$$\frac{V^L - V_c^L}{V^H - V^L} < \frac{N^H}{N^L}$$

Hence, when V^H or N^H are sufficiently high and when time preference is high, we are done⁵.

Hence the corollary says that intermediate learning costs are likely to incite the firm to avoid setting up a non costly protection. Indeed, for piracy to increase profit, the learning cost must be sufficiently high, otherwise the second period price, which incorporates the learning cost in the absence of piracy and the utility of using the pirated product in the presence of piracy, decreases in the presence of piracy. Moreover, the learning cost must also be sufficiently low, otherwise either the rationality constraint forces the firm to lower the second period price, or L-type agents do not pirate the product in period one, or the firm prefers not to discriminate.

References

Banerjee, D. S., 2003, Software piracy: a strategic analysis and policy instruments, *International Journal of Industrial Organization*, **21**, 97-127.

Chen, Y and I. Png, 2003, Information Goods Pricing and Copyright Enforcement: Welfare Analysis, *Information Systems Research*, **14**.

⁵For instance, the constraint that, when piracy is not an option, discriminating is better than no discrimination is satisfied if $\frac{V^H}{V^L} > \frac{N^H + N^L}{N^H}$ (whatever value of $\beta < 1$).

Conner, K. R. and R. P. Rumelt, 1991, Software piracy: an analysis of protection strategies, *Management Science*, **37**, 125-139.

Peitz, M. and P. Waelbroeck, 2003, Piracy of digital products: a critical review of the economics literature, CESifo Working Paper Series No. 1071.

Poddar, S., 2002, Economics of software piracy and it's global impact, National University of Singapore.

Seventh Annual BSA Global Software - Piracy Study, june 2002.

Shy, O. and J.-F. Thisse, 1999, A strategic approach to software protection, *Journal of Economics and Management Strategy*, **8**, 163-190.

Slive, J. and D. Bernhardt, 1998, Pirated for profit, *Canadian Journal of Economics*, **31**, 886-899.

Takeyama, L. N., 1994, The welfare implications of unauthorized reproduction of intellectual property in the presence of demand network externalities, *Journal of Industrial Economics*, **62**, 155-166.

Takeyama, L. N., 1997, The intertemporal consequences of unauthorized reproduction of intellectual property, *Journal of Law and Economics*, **40**, 511-522.

Tehrani, J., 2003, Optimizing piracy: the uses and limits of intellectual property enforcement in the cyberspace, SSRN Working Paper.

Varian, H. R., 2001, Economics of Information Technology, the Raffaele Mattioli Lecture, delivered at Bocconi University, Milano, Italy, on November 15-16, 2001.