Department of Economics

Working Paper No. 0516

http://nt2.fas.nus.edu.sg/ecs/pub/wp/wp0516.pdf

Network Externality and Commercial Software Piracy

by

Sougata Poddar

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Sougata Poddar
Department of Economics
National University of Singapore (NUS)
10 Kent Ridge Crescent
Singapore 119260

E-mail: ecssp@nus.edu.sg

December 2005

Abstract

Contrary to the earlier findings under end-users piracy where the existence of strong network externality was shown to be a reason for allowing limited piracy, we find when the piracy is commercial in nature the optimal policy for the original software developer is to protect its product irrespective of the strength of network externality in the software users market.

Keywords: Copyright violations, Commercial/Retail piracy, Network externality, Quality

JEL Classifications: D23, D43, L13, L86

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* I would like to thank anonymous referees for extremely valuable comments on earlier drafts. Financial support from NUS in the form of research grant (R-122-000-040-112) is gratefully acknowledged.

1. Introduction

The pervasiveness of the illegal copying of software is indeed a worldwide phenomenon. So far there are quite a few theoretical studies (see Conner and Rumelt (1991), Takeyama (1994), Slive and Bernhardt (1998), Shy and Thisse (1999) among others) to investigate the economic reason behind widespread end-user piracy (i.e. private coping). These studies provide us some wisdom on the issue of end-user piracy. For example, in some situations the original software developer may not want to stop piracy even when it has the means to do so simply because it can actually be profitable for the software developer to allow limited piracy. The arguments to establish this result basically stands on the feature of network externality that is widely observed in the software users market. It has been shown that when the effect of network externality is strong, allowing piracy by the original software developer can be a profitable option.

However, another type of software piracy that also considerably draws our attention is commercial or retail piracy and none of the above studies explicitly discuss about the case of commercial piracy and the impact of network externality on it.[1] Commercial piracy is prevalent in most developing countries where the laws against piracy or in general enforcement against copyright violations are rather weak.[2] Under commercial piracy, there is a pirate, who generally operates from a make-shift shop (think of it as another firm), who copies the original software and sells to the consumers.[3] In other words, this pirate, in some sense competes with the original producer in the same market by providing a cheaper variety of the original product. The pirate's product usually is not guaranteed, it does not come with any supporting service, and sometimes it

[1] Banerjee (2003) studies commercial piracy, however, the main focus of the paper is to see the impact of monitoring policy over piracy on the welfare of the society. Effects of various policy instruments on aggregate welfare under end-users piracy are studied by Chen and Png (2003), Gayer and Shy (2003) among others.

[2] Widespread corruptions, weak legal systems, bribery are some of the reasons for that. Also in most developing countries, where the computer literacy and the technological know-how are still very low among the average people, buying a ready-made pirated product at a cheap price is rather attractive.

[3] With advanced and sophisticated technological methods, pirated software copies or even copies of copies become almost if not perfectly identical to an original one.

is also not fully reliable. But at the same time, it comes at a lot cheaper price than the original one, and as a result consumers get easily attracted to it.[4]

Now when the nature of piracy is of this type (i.e. commercial type as opposed to end-user type), we want to see the effect of network externality on the existence of piracy and ask the question what would be the optimal policy of the original software developer in regard to piracy and protection. The question is interesting as we will see later that the presence of the commercial pirate expands the market for the original product (through network effect), which is naturally beneficial for the original developer. However, due to competition there is a dampening effect on price as both firms compete in the same market selling (vertically) differentiated products. Thus the question is how the positive effect on demand expansion of the original developer and the negative affect on price combine together. Our result shows that under such circumstances protection as opposed to allowing piracy is always optimal for the original software developer irrespective of the strength of network externality in the software users market.

2. The Model of Commercial Piracy

Consider an original software firm and a commercial pirate.[5] Consumers can buy the original product at a higher price from the software firm or can buy the pirated version from the pirate at a cheaper price. The pirate has the technology to copy the original software and we assume the cost of copying the software is zero. We assume the probability that a pirated software works is q, $q \in (0,1)$ and this probability is common knowledge.[6] We interpret q in the following ways. q serves as a proxy for the quality of the pirated software. Usually when the consumer gets a pirated copy, it does not come with the supporting services, or sometimes some applications may be missing in the

[4] Software users market is quite heterogeneous in nature. There are heavy users (high valued consumers) to very light users (low valued consumers) of software. Heavy users are likely to depend on reliable product, whereas low valued consumers naturally have higher incentive to buy a pirated copy at a cheaper price.

[5] In reality, there could be more than one commercial pirate, or a group of small commercial pirates operate in the product market, but for simplicity in this paper, we just consider one pirate as qualitative results remains unchanged when there are more pirates and all pirates are similar.

[6] $q = 0$ will eliminate the pirated product, while $q = 1$ will make two products identical. Note $q = 1$ is never possible due to the reasons described above.

pirated version. There is no warranty on the pirated software. Hence, the consumer enjoys the benefit of the pirated software only with probability q. The original software is fully guaranteed to work. p_O and p_P are the prices of the original and pirated software respectively. It must be true that $p_O > p_P$.

There is a continuum of consumers indexed by X, $X \in [\theta_L, \theta_H]$, $\theta_H > \theta_L \geq 0$. A consumer's willingness to pay for the software depends on how much he/she values it – measured by X. A high value of X means higher valuation for the software and low value of X means lower valuation for the software. Therefore, one consumer differs from another on the basis of his/her valuation for the particular software. Valuations are uniformly distributed over the interval $[\theta_L, \theta_H]$ and the size of the market is normalized to 1.

Assumption 1: We assume $\theta_H \geq 2\theta_L$ to ensure enough heterogeneity in the market.

A consumer's utility function is given as:

$$U = \begin{cases} X - p_O & \text{if buys original software} \\ qX - p_P & \text{if buys pirated software} \\ 0 & \text{if buys none} \end{cases}$$

Next we introduce the feature of network externality. Since the pirated product is available at a cheaper price, a number of low valued consumers will have an incentive to actually buy the pirated product. This in turn will increase the total number of software users in the society due to the network effect. The network effect also increases the value of the software for any potential buyer.

Under this circumstance, we will consider two situations in the forthcoming analysis. First, where the original developer protects its software (hence no piracy is possible), and secondly, where the original developer does not protect. For simplicity, here we assume that protection is costless and the original developer can just install a protective device into the software that makes coping impossible. Thus, the original developer can choose to keep its software protected or unprotected.

3. Software Protection (No Piracy)

Without piracy, consumers would choose only between either buying the original one or not buying at all.

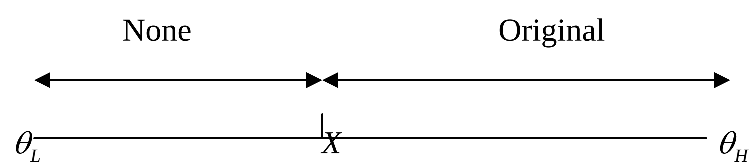
Thus a consumer's utility in the presence of network externality is given by:

$$U = \begin{cases} X + \gamma D_{NP} - P_{NP} & \text{if buys original software} \\ 0 & \text{if buys none} \end{cases}$$

D_{NP} denotes the total demand of the software under protection (i.e. no piracy) [7] and P_{NP} denotes the price of the software. Now $\gamma \geq 0$ is a coefficient which measures the importance of network size to the software users. It can be viewed as the degree or intensity of network externalities. For example, higher γ implies stronger effect of network externality, whereas when γ is close to zero, it implies almost no effect of network externality at all.

Assumption 2: We assume $\theta_H > \theta_L + \gamma$, to have well defined demand and prices in the subsequent analysis.

Figure 1: Distribution of Buyers (Case of Protection)



X is the marginal consumer who is indifferent between buying the original software and not buying any software at all:

$$X + \gamma D_{NP} - P_{NP} = 0$$

$$X = P_{NP} - \gamma D_{NP}$$

Demand for the original software is:

$$D_{NP} = \int_X^{\theta_H} \frac{1}{\theta_H - \theta_L} dx = \frac{\theta_H - P_{NP} + \gamma D_{NP}}{\theta_H - \theta_L}$$

[7] Using notation "NP" in the subscript to denote "no piracy".

$$\Rightarrow D_{NP} = \frac{\theta_H - P_{NP}}{\theta_H - \theta_L - \gamma}$$

Note that assumption 2 ensures the demand is positive.

The monopolist's profit is:

$$\pi_{NP} = \mathrm{P}_{NP} \,.\, \mathrm{D}_{NP} = \mathrm{P}_{NP} \cdot \frac{\theta_H - P_{NP}}{\theta_H - \theta_L - \gamma}$$

Solving for the profit-maximizing monopolist price, we get: $\mathrm{P}^*_{NP} = \frac{\theta_H}{2}$

And demand is:

$$\mathrm{D}^*_{NP} = \frac{\theta_H}{2(\theta_H - \theta_L - \gamma)} \qquad (1)$$

Note that when $\gamma = \frac{\theta_H - 2\theta_L}{2}$ (assumption 1 makes this expression positive)

$D^*_{NP} = 1$ i.e. the full market is served.

Hence the pricing policy of the monopolist is:

$$P^*_{NP} = \frac{\theta_H}{2} \quad \text{when } 0 \le \gamma < \frac{\theta_H - 2\theta_L}{2} \qquad (2)$$

$$= \theta_L + \gamma \quad \text{when } \gamma \ge \frac{\theta_H - 2\theta_L}{2} \qquad (3)$$

The profit of the monopolist software firm is:

$$\pi^*_{NP} = \frac{\theta_H^2}{4(\theta_H - \theta_L - \gamma)} \quad \text{when } 0 \le \gamma < \frac{\theta_H - 2\theta_L}{2} \qquad (4)$$

$$= \theta_L + \gamma \quad \text{when } \gamma \ge \frac{\theta_H - 2\theta_L}{2} \qquad (5)$$

Now consider the case when piracy is allowed by the software firm and there is a commercial pirate.

4. Allowing Software Piracy

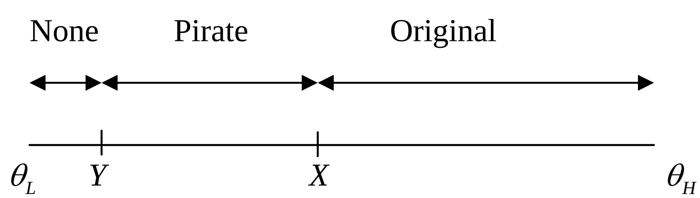
Here consumer's utility is given by:

$$U = \begin{cases} X + \gamma D_O + q\gamma D_P - p_O & \text{if buys original software} \\ qX + q\gamma D_O + q^2\gamma D_P - p_P & \text{if buys pirated software} \\ 0 & \text{if buys none} \end{cases}$$

[8] [9]

D_O, p_O and D_P, p_P are the demand and prices for the original and pirated software respectively. As mentioned earlier, q is the probability that the pirated software works.

Figure 2: Distribution of Buyers (Case of Non-Protection)



Like before, the marginal consumer X, who is indifferent between buying the original software and the pirated version is given by:

$$X + \gamma D_O + q\gamma D_P - p_O = qX + q\gamma D_O + q^2\gamma D_P - p_P$$

$$X = \frac{p_O - p_P}{1-q} - \gamma\left(D_O + qD_P\right)$$

The marginal consumer Y, who is indifferent between buying the pirated software and not buying any software at all is given by:

$$qY + q\gamma D_O + q^2\gamma D_P - p_P = 0$$

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[8] Since the consumer buys original software, he gets to enjoy the benefit *X* and the network externality generated by those who also buy original software with certainty. However, he only gets to enjoy the network created by those who buy pirated software with probability *q* since only there is only a *q* chance that it works.

[9] Since this consumer buys pirated software, he gets to enjoy the benefit and the network effect created by both legal and illegal users if and only if his software works.

$$Y = \frac{p_P}{q} - \gamma\left(D_O + qD_P\right)$$

The demand for the original software is given by:

$$D_O = \int_X^{\theta_H} \frac{1}{\theta_H - \theta_L} dx$$

The demand for pirated software is given by:

$$D_P = \int_Y^X \frac{1}{\theta_H - \theta_L} dx = \frac{1}{\theta_H - \theta_L}\left[\frac{qp_O - p_P}{q(1-q)}\right]$$

Thus, $D_O = \frac{1}{\theta_H - \theta_L - \gamma}\left[\theta_H - \frac{p_O - p_P}{1-q} + \frac{\gamma q}{\theta_H - \theta_L}\left(\frac{qp_O - p_P}{q(1-q)}\right)\right]$

The original firm and the pirate compete by choosing price strategically. The respective reaction functions are given by:

$$p_O\left(p_P\right) = \frac{\theta_H - \theta_L}{2\left(\theta_H - \theta_L - \gamma q\right)}\left[\theta_H\left(1-q\right) + p_P\left(1 - \frac{\gamma}{\theta_H - \theta_L}\right)\right]$$

$$p_P\left(p_O\right) = \frac{qp_O}{2}$$

Hence, Nash Equilibrium prices are:

$$p_O^* = \frac{2\left(\theta_H - \theta_L\right)\left(1-q\right)\theta_H}{\left(\theta_H - \theta_L\right)\left(4-q\right) - 3\gamma q} \qquad (6)$$

$$p_P^* = \frac{q\left(1-q\right)\left(\theta_H - \theta_L\right)\theta_H}{\left(\theta_H - \theta_L\right)\left(4-q\right) - 3\gamma q} \qquad (7)$$

Equilibrium demands are:

$$D_O^* = \frac{\theta_H}{\left(\theta_H - \theta_L - \gamma\right)}\left[\frac{2\left(\theta_H - \theta_L - \gamma q\right)}{\left(\theta_H - \theta_L\right)\left(4-q\right) - 3\gamma q}\right] \qquad (8)$$

$$D_P^* = \frac{\theta_H}{\left(\theta_H - \theta_L\right)\left(4-q\right) - 3\gamma q} \qquad (9)$$

The profit of the original software firm is:

$$\pi_O^* = \frac{4\theta_H^2\left(\theta_H - \theta_L\right)\left(1-q\right)\left(\theta_H - \theta_L - \gamma q\right)^2}{\left(\theta_H - \theta_L - \gamma\right)\left[\left(\theta_H - \theta_L\right)\left(4-q\right) - 3\gamma q\right]^2} \qquad (10)$$

and that of the pirate is: $\pi_P^* = \dfrac{\theta_H^2 q(1-q)(\theta_H - \theta_L)}{\left[(\theta_H - \theta_L)(4-q) - 3\gamma q\right]^2}$ (11)

There will be an upper bound of the network effect γ for which $D_O^* + D_P^* = 1$. Suppose that upper bound is $\hat{\gamma}$. Now $\hat{\gamma}$ is necessarily less than $\dfrac{\theta_H - 2\theta_L}{2}$ (see previous section 3) as the size of the market served under duopoly is unambiguously larger than the size of the monopoly market under protection. Hence, when $0 \le \gamma < \dfrac{\theta_H - 2\theta_L}{2}$, comparisons between prices ((1) and (8)); demands ((2) and (6)); and profits ((4) and (10)) under the previous monopoly and the present duopoly case are legitimate. The following two results summarize the impact of the presence of the commercial pirate in the market of the software developer.

Lemma 1

The demand for the original firm under piracy is higher than its demand under protection, while price under piracy is lower than under protection.

Formally, $D_O^* > D_{NP}^*$ *and* $p_O^* < P_{NP}^*$.

Proof: From (1) and (8), we get $D_O^* - D_{NP}^* = \dfrac{\theta_H q}{2\left[(\theta_H - \theta_L)(4-q) - 3\gamma q\right]} > 0$

From (2) and (6) we have,

$$P_{NP}^* - p_O^* = \frac{3\theta_H(\theta_H - \theta_L - \gamma)q}{2\left[(\theta_H - \theta_L)(4-q) - 3\gamma q\right]} > 0.$$

Interestingly, we note that the presence of the commercial pirate has a positive effect on the original firm's demand. Allowing the pirate expands the market for the original product. However, due to competition there is a dampening effect on price as both firms compete in the same market selling differentiated products.

Lemma 2 $D_O - D_{NP}$ *is an increasing function of* γ.

Thus increase in the demand for the software developer due to presence of the pirate increases with the intensity of network externality.

5. Optimal Choice: Protection versus Non-Protection

We are interested to see how the positive effect on demand of the original software firm and the negative affect on price combine together to determine the net effect on the profit of the software firm.

Proposition

Given a choice between employing protection and non-protection, it is always profitable for the original software developer to protect its software from the commercial pirate. Formally, $\pi_{NP}^{*} > \pi_{O}^{*}$ for all $\gamma \geq 0$.

Proof: <u>Case 1:</u> $0 \leq \gamma < \dfrac{\theta_H - 2\theta_L}{2}$

$$\pi_{NP}^{*} - \pi_{O}^{*} = \frac{\theta_H^2}{4(\theta_H - \theta_L - \gamma)} - \frac{4\theta_H^2(\theta_H - \theta_L)(1-q)(\theta_H - \theta_L - \gamma q)^2}{(\theta_H - \theta_L - \gamma)\left[(\theta_H - \theta_L)(4-q) - 3\gamma q\right]^2}$$

Now, $\pi_{NP}^{*} > \pi_{O}^{*}$ if $\dfrac{1}{4} - \dfrac{4(\theta_H - \theta_L)(1-q)(\theta_H - \theta_L - \gamma q)^2}{\left[(\theta_H - \theta_L)(4-q) - 3\gamma q\right]^2} > 0$

Simplifying implies the above is true when $\gamma < \dfrac{2(\theta_H - \theta_L)}{2+q}$. Now given that $\dfrac{\theta_H - 2\theta_L}{2} < \dfrac{2(\theta_H - \theta_L)}{2+q}$ the above is always true, hence the result.

<u>Case 2:</u> $\gamma \geq \dfrac{\theta_H - 2\theta_L}{2}$

In this case, full market is served under monopoly as well as duopoly. However, for a given degree of network externality, when original developer is the monopolist and serves the entire market it must earn a higher profit than when it shares the market with a competitor and jointly serves the full market.

Q.E.D.

Thus, we find that the above proposition is true irrespective of the value of γ i.e. irrespective of the strength of network externality. No matter how strong is the network effect, it is never profitable for the original software developer to allow the commercial pirate. This result is in complete contrast with the previous findings under end users piracy where existence of allowing limited piracy is rationalized under the presence of strong demand network externality. We also find that this result is also independent of the quality and reliability (q) of the pirated copies. In that sense this result of choosing full protection of the software by the original developer turns out to be robust as well.

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