United Nations University

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World Institute for Development Economics Research

Discussion Paper No. 2002/115

Network Externality and Software Piracy

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December 2002

Abstract

The pervasiveness of the illegal copying of software is a worldwide phenomenon. Software piracy implies a huge loss of potential customers of original software buyers, which directly translates into revenue losses for the software industry. Given this, conventional wisdom would suggest the need for the legal software firms and governments to take a harsh approach on piracy of software. Interestingly, there is a trend of literature, which establishes that it is actually profitable for the original software developer to allow limited piracy in the presence of network externality. The present paper wishes to demonstrate that these results cannot be accepted as a general explanation for the existence of software piracy in the real world. To prove the point, this paper comes up with a model where it shows that in the presence of intense effect of network externality, protection as opposed to allowing piracy is always optimal for the original software developer. It also shows that the incentive to protect is even higher with the presence of network externality as opposed to the case of no network externality. Whether piracy is profitable or not to the original developer depends on the market structure, demand environment and the nature of the competition.

Keywords: copyright, software piracy, network externality, market structure, competition

JEL classification: D23, D43, L13, L86

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This is a revised version of the paper originally prepared for the UNU/WIDER Conference on the New Economy in Development, 10-11 May 2002, Helsinki.

Acknowledgements

I would like to thank the participants of the LAMES (2002) in Sao Paulo, the UNU/WIDER conference on the New Economy in Development in Helsinki (2002), WEA Annual conference (2001) in San Francisco, International Conference on Copyright in the Cultural Industries (2000) in Rotterdam, seminar in Groningen University, Netherlands (2002) and an anonymous referee for extremely valuable comments. Financial support in the form of research grant from National University of Singapore is gratefully acknowledged.

UNU World Institute for Development Economics Research (UNU/WIDER)
Katajanokanlaituri 6 B, 00160 Helsinki, Finland

Camera-ready typescript prepared by Liisa Roponen at UNU/WIDER
Printed at UNU/WIDER, Helsinki

ISSN 1609-5774
ISBN 92-9190-370-1 (printed publication)
ISBN 92-9190-371-X (internet publication)

1 Introduction

The pervasiveness of the illegal copying of software is a worldwide phenomenon. It not only has a profound effect on the users of the software, but also on the software industry as a whole. It also has a tremendous effect on the development of digital intellectual properties and technologies.

Software piracy is rampant because of the very nature of the product. Software production incurs large development costs, but once developed, the manufacturing costs of replicating a copy of a software programme are almost negligible. In other words, duplicated copies of an original software incur zero costs and this is precisely why software piracy presents such a lucrative and effective option for those who are out to make a quick profit.[1] This implies a huge loss of potential customers of original software buyers, which directly translates into revenue losses for the software industry. Software manufacturers have been asserting, through their trade organizations, the huge damages inflicted on their businesses by the illegal use of software. According to the Business Software Alliance (BSA), in 1995 the industry lost US$ 13 billion per year, US$ 35 million per day, and US$ 407 per second from software piracy. The *1998 Global Software Piracy Report* released (in May 1999) by the BSA and the Software and Information Industry Association (SIIA), the two leading trade associations for the software industry, estimate that of the 615 million new business software applications installed worldwide during 1998, 231 million (or 38 per cent) were pirated. In other words, one out of every three software applications installed worldwide in 1998 was a pirate version! In 2001, the corresponding figure is 40 per cent.[2] Revenue losses to the global software industry due to piracy are estimated at US$ 10.97 billion. Asia, North America, and Western Europe account for the majority of world revenue losses. In 2001, the total losses for these countries stood at US$ 9.4 billion, while Asia alone accounted for a loss of US$ 4.7 billion.

These losses not only pose a serious constraint on the growth of the software industry but also adversely affect investment decisions and limit the development of software products in regions where piracy is prevalent. At the same time, rampant piracy inhibits job creation and government revenue contributions. As a matter of fact, PriceWaterhouseCoopers (1998) estimated that if world governments had reduced software piracy rates to benchmark levels,[3] direct and indirect employment would have increased by 521,663 jobs and tax revenues by as much as US$ 13.7 billion in 1996/97 alone for the non-US economy. For the US economy, reducing piracy would have generated additional 130,000 jobs and nearly US$ 1.0 billion in tax revenues in 1996. And this problem of software piracy only gets bigger with the revolution and intensification of the Internet. ‘What Do You Want to Pirate Today?’ reads a banner at one of the many sites that can be found by any user doing a basic Internet search for the word ‘warez’—the online term for unlicensed programmes. The emergence of the ‘web’

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1 With advanced and sophisticated technological methods, pirated software copies or even copies of copies become almost, if not perfectly, identical to the original.

2 In Vietnam only 6 per cent software is legitimate while in US 26 per cent of the software is pirated (BSA 2002).

3 Benchmark levels vary from country to country and from one software category to another. For PC business software, benchmark levels of 26 per cent (the rate currently experienced in the US) were used for most countries, and a rate of zero per cent was used for the United States and Japan.

has added a new dimension to software piracy by permitting electronic sales and transmissions of illegal software on a grand scale.

Given this, conventional wisdom suggests the need for legal software firms and governments to take a harsh approach on piracy of software. Interestingly, a group of economists would ask the question: is the original software developer or the government or the controlling authority in reality seriously interested in stopping piracy? In their recent work, they actually show that the answer is not necessarily positive. This strand of literature (Conner and Rumelt 1991; Takeyama 1994; Slive and Bernhardt 1998; Shy and Thisse 1999 among others) provides us with unconventional wisdom on the issue of software piracy. It shows that in some situations even the original software developer may not necessarily want to clamp down on piracy even when the developer has the means to do so. In other words, it is actually profitable for the original software developer to allow limited piracy.

The argument to establish this assumption basically stands on the feature of network externality that is observed in the software user market.[4] It is true that the occurrence of network externality is a very prevalent feature in the software market and its existence plays a central role for this (piracy) phenomenon. But we argue in this paper that all these new unconventional results cannot be accepted as the general explanation for the existence of software piracy in the real world. To prove the point, this paper comes up with a model where it shows that even in the presence of the intense effect of network externality, protection as opposed to allowing piracy is always optimal for the original software developer. It also shows that the incentive to protect is even higher with the presence of network externality as opposed to the case of no network externality. Therefore to understand the real reason for the existence of software piracy, one needs to have a closer look at the real markets instead of building a hypothetical model and to come up with some conclusion, i.e., whether piracy is profitable or not to the original developer depends on the market structure, demand environment and the nature of the competition.

The plan of the paper is as follows. In the next section, we give a brief survey of the literature, which argues that in the presence of strong network externality, it is profitable for the original software firm to allow limited piracy. In section 3, we set up our model where we demonstrate in the subsequent sections that the above explanation for the existence of piracy cannot be accepted as a general argument. We describe the original software firm's response to piracy with and without the effect of network externality when there is a software pirate in the market. A comparison covering the presence and the absence of network externality is made on the optimal policy for protection by the original software firm. Finally, we conclude in section 4 with a discussion.

4 The idea of network externality stems from the work of Katz and Shapiro (1985) (see also Rohlfs 1974, Gandal 1994, and Shy 1995). Generally, the idea is that the utility that a given user derives from a product depends upon the number of other users who consume the same product. In other words, consumers' preferences are said to exhibit network externality if the utility of each consumer increases with the cumulative number of other consumers purchasing the same brand. When this is the case, each additional purchase raises the value to existing users as well as the expected value to future adopters. A classic example of a product that exhibits such a characteristic is the telephone network.

2 Network externality—a reason for piracy

Takeyama (1994) considers a model of unauthorized reproduction of intellectual property in the presence of demand network externalities and shows that unauthorized copying can induce greater profits to the original firm. She considers a discreet demand model with two groups of consumers, who have different valuations for a good and analyses situations when copying is easily possible by the users and when cost of copying is prohibitively high, hence not possible. In these two contrasting situations, she shows that if the network effect is sufficiently large, profits for the firm are higher with copying than without copying. This result follows from the fact that unauthorized copying can be a relatively efficient means of increasing network size. In effect, unauthorized copying allows the firm to price discriminate among different classes of consumers. With copying, large network size can be achieved through the existence of marginal consumers making the reproductions (at zero cost to the firm), while inframarginal consumers purchase originals at a price that may largely appropriate the externality of the increased network size created by copiers. Without copying, the same network size may only be achieved at a possibly lower price on all existing units. An increase in network size increase the value of the product unambiguously to all consumers therefore enabling firms to raise the price to those who buy it from the firm.

In other papers, Conner and Rumelt (1991) and Slive and Bernhardt (1998) comes up with a similar finding to explain why a software manufacturer would permit limited piracy of its product. These studies are concentrated in a situation where there is only one original manufacturer, in other words, a monopolistic industry. On the other hand, a strategic approach to software piracy is found in Shy and Thisse (1999). They show that there is a strategic reason why software firms have agreed to the consumer wish of dropping software protection. They analyse software protection policies in a price-setting duopoly software industry selling differentiated software packages, where also consumers' preference for particular software is affected by the number of other consumers who (legally or illegally) use the same software. Their results show when firms protect their software, a low-price equilibrium emerges if network effects are strong, whereas a high-price equilibrium arises under weak network effects. Therefore, all firms are better off with software protection when network effects are weak.

By contrast, firms prefer not to protect their software when network effects are strong. In another set of results dealing with the market situation in which firms choose to protect or not to protect prior to price competition, they found that for very weak network effects, both firms choose to protect their software because the impact of piracy on sales is insignificant. For intermediate value of the network effects, one firm chooses to protect whereas the other does not. This is because the network effects are now strong enough to induce one firm to go unprotected, thereby benefiting from the larger network size, whereas these effects are still too low for the other firm to be able to afford to do the same. Furthermore, the non-protected firm earns a higher profit than the protected firm. Finally, when network effects are sufficiently strong, both firms choose non-protection.

Hence, all these studies unambiguously try to make the point that the existence of strong demand network externalities is the central reason for the existence of piracy. In the following section, we lay out a model of software piracy with the feature of network externality and show that above arguments are not generally valid.

3 Network externality: a reason for protection

3.1 The model

Consider an original software firm and a pirate software firm. The pirate firm has the technology to copy the original software. In reality, we know that the cost of copying software is negligible, hence we assume the cost of copying is zero for the pirate. The probability that pirated software works is q, $q \in [0,1]$ and this probability is common knowledge. Therefore q serves as a proxy for the quality of the pirated software. Usually pirated copies do not come with the supporting services, so that it can be assumed that even if the pirated software is exactly same as the original (because of digital coping), the lack of supporting service does not allow the user to get full value of the pirated software, hence quality of the pirated software q can also be interpreted like this. For simplicity, we also assume that the marginal costs of software production (i.e. making copies) are nil for both firms.[5]

There is a continuum of consumers indexed by X, $X \in [0,1]$. Consumer 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, whereas low value of X means lower valuation for the software. Therefore, one consumer differs from another on the basis of his valuation for the particular software. Valuations are uniformly distributed over the interval $[0,1]$ and the size of the market is normalized to 1.

A consumer's utility function is given as:

$$U = \begin{cases} X - P_O & \text{if buys original software} \\ q\,X - P_P & \text{if buys pirated software}^{6} \\ 0 & \text{if buys none.} \end{cases}$$

There is no way a consumer can get defected pirated software replaced since there is no warranty for it.[7] Hence, the consumer enjoys the benefit of the pirated software only with probability *q*. In the event that the purchased pirated software does not work at all, the loss to the consumer is the price paid for it. 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 $P_O > P_P$. $P_O - P_P$ can be viewed as the premium a consumer pays for buying 'guaranteed-to-work' software.

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5 Presumably, the original developer had incurred some fixed cost (like R&D to develop the software) which is sunk now. The cost of making a copy of the software is negligible.

6 $q\,X - P_P = q\,(X - P_P) + (1 - q)(- P_P)$. If the pirated software does not work, consumer does not derive any benefit from the software and incurs instead only a loss equivalent to the amount paid for the pirated software.

7 In most markets, pirates operate using some makeshift arrangement: if the pirated software turns out to be defected, there is no chance of getting software replaced.

3.2 Legal software firm’s response to piracy (without network externality)

We will consider two cases in turn; first, where the original developer protects its software, and second, where the original developer does not protect it.[8]

3.2.1 Software protection (no piracy)

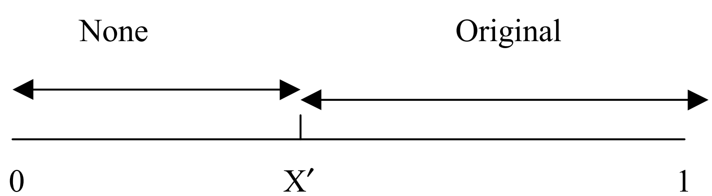
Assume that the legal software firm possesses the means of protecting its software packages, thus making software piracy impossible or unprofitable for the software pirate. For example, it may set up the software in such a way that a special plug or a chip is necessary to launch the application. In order to highlight the strategic implications of protection, it is assumed that software protection has negligible cost for the software firm. Now, the original software firm is the monopolist software provider in the market, and consumers are left with only one software choice—the original one. Depending on their valuation for the software, they can choose between either buying the original one or not buying at all.

Hence, the utility levels now are given as:

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

where P_{NP} is the monopoly software price when no piracy takes place. Hereafter, the subscript ‘NP’ always stands for no piracy case.

Figure 1
Distribution of buyers (protection)



We can see that the marginal consumer, X′, who is indifferent to buying the original software and not buying, is:

$$X' - P_{NP} = 0$$
$$X' = P_{NP}$$

Demand for the original software is:

$$D_{NP} = 1 - X' = 1 - P_{NP}$$

[8] The effects of installing protection into software already on the market as well as monitoring piracy have been analysed in Chen and Png (1999) and Banerjee (2002), among others.

The monopolist's profit is:

$$\pi_{NP} = D_{NP} \,.\, P_{NP} = P_{NP}\,(1 - P_{NP})$$

The profit-maximizing monopolist price is:

$$P^{*}_{NP} = \frac{1}{2} \qquad (1)$$

Monopoly demand is:

$$D^{*}_{NP} = \frac{1}{2} \qquad (2)$$

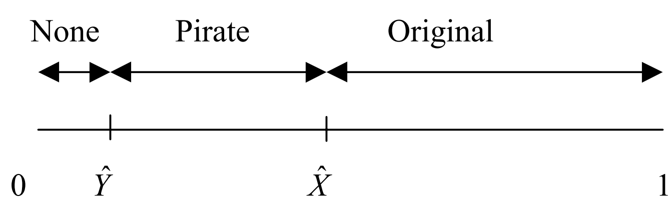
Hence, profits of the monopolist software firm in the case of protection are given as:

$$\pi^{*}_{NP} = \frac{1}{4} \qquad (3)$$

3.2.2 No software protection (piracy)

Now consider the case where the original software developer does not protect the software. Here, a pirate comes and competes for a share of the software market with the original software firm.

Figure 2
Distribution of buyers (non-protection)



The marginal consumer, $\hat{X}$, who is indifferent to buying the original software and the pirated version is given by:

$$\hat{X} - P_O = q\,\hat{X} - P_P$$

$$\hat{X} = \frac{P_O - P_P}{1 - q}$$

The marginal consumer, $\hat{Y}$, who is indifferent between buying the pirated software and not buying any software is:

$$q\,\hat{Y} - P_P = 0$$

$$\hat{Y} = \frac{P_P}{q}$$

Thus the demand for original software is:

$$D_O = (1 - \hat{X}) = 1 - \frac{P_O - P_P}{1 - q}$$

Demand for pirated software is:

$$D_P = \hat{X} - \hat{Y} = \frac{qP_O - P_P}{q(1-q)}$$

The two firms engage in a Bertrand game of price competition and determine the profit maximizing prices of the respective products.

The profit functions of the original software firm and the pirate are respectively:

$$\pi_O = D_O \,.\, P_O = P_O \,.\, 1 - \left[\frac{P_O - P_P}{1 - q}\right]$$

$$\pi_P = D_P \,.\, P_P = P_P \left[\frac{qP_O - P_P}{q(1-q)}\right]$$

From the first order profit-maximizing conditions, we get the following reaction functions of the original software developer and the pirate:

$$P_O\,(P_P) = \frac{1 - q + P_P}{2}$$

$$P_P\,(P_O) = \frac{qP_O}{2}$$

The Nash Equilibrium prices are given by:

$$P^*_O = \frac{2 - 2q}{4 - q} \qquad (4)$$

$$P^*_P = \frac{q - q^2}{(4 - q)} \qquad (5)$$ [9]

Equilibrium demands are given by:

$$D^*_O = \frac{2}{4 - q} \qquad (6)$$

$$D^*_P = \frac{1}{4 - q} \qquad (7)$$

9 Observe that $P^*_O > P^*_P$.

Hence, profit of the original software firm in the case of non-protection is:

$$\pi^*_O = \left(\frac{2-2q}{4-q}\right)\left(\frac{2}{4-q}\right) = \frac{4(1-q)}{(4-q)^2} \tag{8}$$

and that of pirate is:

$$\pi^*_P = \frac{q(1-q)}{(4-q)^2} \tag{9}$$

3.2.3 Protection versus non-protection

Now we are in a position to compare the profits of the original software firm under protection and non-protection policy.

Proposition 1

Given a choice between protection and non-protection, it is always profitable for the original software developer to protect its software.

Proof: It is easy to show that π^*_O is a decreasing function of q, and $\pi^*_O = (1/4)$ when $q = 0$. Hence, $\pi^*_O < \pi^*_{NP}$ for all $q \in (0,1]$.

So far, we have not introduced the feature of network externality in the model. But it is a fact that network externality is a very prevalent feature in the software user market. So to capture a more realistic picture of the software market, we introduce it now.

3.3 Legal software firm's response to piracy (with network externality)

Generally speaking, network externality means that as more and more consumers use a certain product, the value of that product increases. In other words, the utility a consumer derives from using the product increases with the number of consumers using it. In our model, it implies that the value of a particular piece of software for a consumer increases as more and more consumers use it. With the presence of a pirate and due to the lower price of the pirated software, more people tend to buy the software, which in turn increase the number of software users in the society. This intensifies the network effect, and as a result, this increases the value of that software for any potential buyers (both legal and illegal). Under this situation, we will consider, as before, two cases (namely protection and non-protection) in turn.

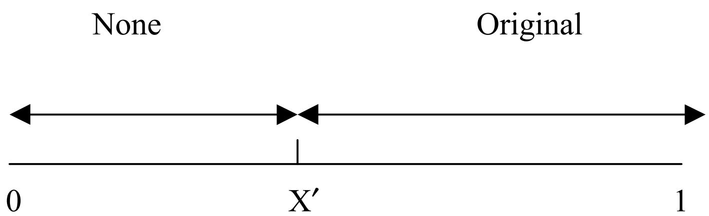
3.3.1 Software protection (no piracy)

Without piracy, consumers would again choose only between either buying the original software or not buying depending on their valuation of the software. Hence, the utility levels are given as:

$$U' = \begin{cases} X + \theta D'_{NP} - P'_{NP} & \text{if buys original software} \\ 0 & \text{if buys none.} \end{cases}$$

D'_{NP} denotes the total demand of the software under protection (i.e. no piracy) and P'_{NP} denotes the price. $\theta \in [0,1/2]$[10] is a coefficient which measures the importance of the network size to the software user. It can be viewed as the degree of network externalities. For example, if θ is close to 1/2, it implies intense effect of network externality and when θ is close to zero, there is almost no effect of any network externality at all.

Figure 3
Distribution of buyers (protection with network externality)



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

$$X' + \theta D'_{NP} - P'_{NP} = 0$$
$$X' = P'_{NP} - \theta D'_{NP}$$

Demand for the original software is:

$$D'_{NP} = 1 - X' = 1 - P'_{NP} + \theta D'_{NP} \Rightarrow D'_{NP} = \frac{1 - P'_{NP}}{1 - \theta}$$

The monopolist's profit is:

$$\pi'_{NP} = P'_{NP} \cdot D'_{NP} = P'_{NP} \cdot \frac{1 - P'_{NP}}{1 - \theta}$$

Similarly, solving for the profit-maximizing monopolist price gives:

$$P'^{*}_{NP} = \frac{1}{2} \qquad (10)$$

And demand is:

$$D'^{*}_{NP} = \frac{1}{2(1 - \theta)} \qquad (11)$$

Note that when $\theta = 1/2$, $D'^{*}_{NP} = 1$, i.e. the full market is served.

10 Network effect is bounded by 1/2 because $\theta = 1/2$ is enough to serve the full market under monopoly.

Hence, the profit of the monopolist software firm in the case of protection (with network externality) is:

$$\pi'^{*}_{NP} = \frac{1}{4(1-\theta)} \tag{12}$$

Notice that as $\theta \to 0$, $\pi'^{*}_{NP} \to 1/4$.

3.3.2 No software protection (piracy)

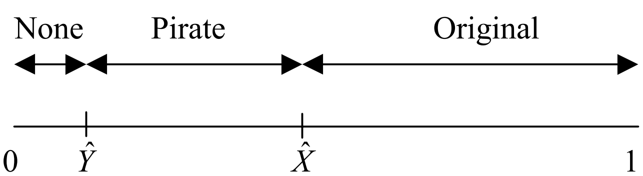
This time, a consumer's utility function is given as:

$$U = \begin{cases} X + \theta D'_O + q\,\theta D'_P - P'_O & \text{if buys original software}^{11} \\ q X + q\,\theta D'_O + q^2\,\theta D'_P - P'_P & \text{if buys pirated software}^{12} \\ 0 & \text{if buys none} \end{cases}$$

D'_O, P'_O and D'_P, P'_P are the demand and prices for the original and pirated software respectively (with presence of network externality).

As mentioned earlier, q is the probability that the pirated software works. This time, though, the loss to the consumer if the pirated software does not work comprise of the price paid for the illegal software and the intangible cost which arises from not being able to enjoy the positive network externality.

Figure 4
Distribution of buyers (non-protection with network externality)



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

$$\hat{X} + \theta D'_O + q\,\theta D'_P - P'_O = q\hat{X} + q\,\theta D'_O + q^2\,\theta D'_P - P'_P$$

$$\hat{X} = \frac{P'_O - P'_P}{1-q} - \theta\left(D'_O + qD'_P\right).$$

[11] 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.

[12] 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.

The marginal consumer, $\hat{Y}$, who is indifferent between buying the pirated software and not buying any software at all is:

$$q\hat{Y} + q\,\theta\,D'_O + q^2\,\theta\,D'_P - P'_P = 0$$
$$\hat{Y} = \frac{P'_P}{q} - \theta\left(D'_O + qD'_P\right).$$

Again, the demand for original software is given by:

$$D'_O = 1 - \hat{X} \Rightarrow D'_O = \frac{(1-q)+\theta\left(qP'_O - P'_P\right)-\left(P'_O - P'_P\right)}{(1-q)(1-\theta)}.$$

and the demand for pirated software is:

$$D'_P = \hat{X} - \hat{Y} \Rightarrow D'_P = \frac{qP'_O - P'_P}{q(1-q)}.$$

The first order profit-maximizing reaction functions are:

$$P'_O\,(P'_P) = \frac{1-q+P'_P\,(1-\theta)}{2(1-\theta q)}$$
$$P'_P\,(P'_O) = \frac{qP'_O}{2}.$$

Nash Equilibrium prices are:

$$P'^*_O = \frac{2(1-q)}{4-q-3\theta\,q} \tag{13}$$
$$P'^*_P = \frac{q(1-q)}{4-q-3\theta\,q}. \tag{14}$$

Equilibrium demands are:

$$D'^*_O = \frac{1}{1-\theta}\left[\frac{2-2\theta\,q}{4-q-3\theta\,q}\right] \tag{15}$$
$$D'^*_P = \frac{1}{4-q-3\theta\,q} \tag{16}$$

The profit of the original software firm in the case of piracy (with network externality) is:

$$\pi^{**}_O = \frac{4(1-q)(1-\theta q)}{(1-\theta)(4-q-3\theta\,q)^2} \tag{17}$$

and that of pirate is:

$$\pi^{**}{}_{P} = \frac{q(1-q)}{(4-q-3\theta\, q)^2}\,. \tag{18}$$

Lemma 1

Demand from the original firm and the pirate is higher in the presence of network externality as opposed to no network externality. Formally, $D'^{*}{}_{O} \geq D^{*}{}_{O}$ *and* $D'^{*}{}_{P} \geq D^{*}{}_{P}$.

Proof: Observe that $D'^{*}{}_{O}$ is increasing in θ and $D'^{*}{}_{O} = D^{*}{}_{O}$ when $\theta = 0$. For the other one it directly follows from the expressions, see (7) and (16).

Lemma 2

Presence of network externality increases the prices of the original firm and the pirate when compared with no externality situation. Formally, $P'^{*}{}_{O} \geq P^{*}{}_{O}$ *and* $P'^{*}{}_{P} \geq P^{*}{}_{P}$.

Proof: Compare (4) with (13) and (5) with (14).

Lemma 3

Profit of the pirate is higher under the presence of network externality, i.e. $\pi^{**}{}_{P} \geq \pi^{*}{}_{P}$.

Proof: Comparing the expressions in (9) and (18).

Now, the following result summarizes the impact of the presence of the pirate in the market under network externality.

Proposition 2

In the presence of network externality, when the pirate is present in the market, the demand for the original firm 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: Follows after comparing (and simplifying) (11) with (15) and (10) with (13).

So under network externality, the presence of the pirate has a positive effect on the original firm's demand and a dampening effect on the price due to competition. Under this, we are interested to see how these two opposing effects combine and what would be a more profitable situation for the original firm between piracy and protection.

3.3.3 Protection versus non-protection

We compare the profits of the original software firm under protection as opposed to non-protection.

Proposition 3

In the presence of network externality given a choice between employing protection and non-protection, it is always profitable for the original software developer to protect its software.

Proof: To show that $\pi'^{*}{}_{NP} - \pi^{**}{}_{O} \geq 0$.

Observe that:

$$\pi'^{*}_{NP} - \pi^{**}_{O} = \frac{1}{(1-\theta)}\left[\frac{1}{4} - \frac{4(1-q)(1-\theta q)}{(4-q-3\theta q)^2}\right] = \frac{q^2 - 8q\theta - 10\theta q^2 + 8q + 9\theta^2 q^2}{4(1-\theta)(4-q-3\theta q)^2}.$$

The denominator of the above expression is non-negative. We have to show that the numerator is non-negative for all θ and q.

Simplifying the numerator, we get $(1 - \theta)[8q - q^2(9\theta - 1)]$, to make it positive we must have $\theta \le \frac{8+q}{9q}$ which is always true for all $q \in (0,1]$ and $\theta \in [0, 1/2]$. Note that $\frac{8+q}{9q}$ is decreasing in q. Hence, the proposition.

This result is interesting since under network externality, when the pirate is present in market, even if there is positive effect on the demand of the original firm, still the more profitable situation for the firm, is to protect.

<u>Proposition 4</u>

The original software developer has got higher incentive to protect its product in the presence of network externality as oppose to the case of without any network externality.

Proof: Gain from protection with network externality is $\frac{q(8+q-9q\theta)}{4(4-q-3\theta q)^2} = G^1$ (say).

Gain from protection without network externality is $\frac{q(8+q)}{4(4-q)^2} = G^2$ (say).

At $\theta = 0$, we have $G^1 = G^2$. Observe that G^1 is an increasing function of θ. This concludes the proof.

4 Discussion

In this paper, we tried to argue that the prevalence of network externality in the software user market cannot generally be held as the reason for software piracy. We showed that in some situations, even with very strong network effect, protection instead of allowing piracy, is the optimal measure for the original software developer. To this end one might argue that in our model since deterring the pirate (or protection) is costless to the original software firm, the original firm will always deter the pirate and enjoy the monopoly market simply because monopoly profit is always higher than duopoly profit. Now one should also note that this argument is valid only in the first situation where there is no network externality. When we have network externality, then the presence of the pirate increases the demand of the original firm compared to the case of full protection. This is clearly a positive effect of allowing piracy. Although there exists a dampening effect on the price under piracy due to competition, but a priori it is not quite clear which effect dominates and eventually which situation would be more profitable to the original firm.

Our study also shows that all the results regarding software piracy that we derive (or generally the literature talks about) depend very much on the type of models and the underlying assumptions within them. In other words, all results are very model specific. Digging little bit deeper, we realize that the market structure, the nature of competition and the demand structure play a very crucial role in driving all these results. For example, when the market structure is monopolistic with two types of consumers, software piracy allows price-discriminate among the different classes of consumers (see Conner and Rumelt 1991; Takeyama 1994; and Slive and Bernhardt 1998). On the other hand, when the market structure is duopolistic (or strategic in general), the results regarding the existence (or non-existence) of software piracy depends on the nature of competition between the competing firms. For example, when competition takes place between two *symmetric* firms (both are original software developers, but their products are differentiated) (see Shy and Thisse 1999), then allowing software piracy by one group of software users (typically low-valued users) could be supported as a non-cooperative equilibrium under strong network effect. At the same time, when the competition takes place between two *asymmetric* firms, i.e. one is the original software developer and the other is just a pirate (as in this paper), then allowing piracy (by the pirate) is not a profitable outcome for the original firm. Therefore, protection remains the only profitable option to the original developer.

Therefore, all these studies suggest that the existence (or non-existence) of software piracy in real life markets depends on the particulars of the market we are focusing on. So when we try to explain issues regarding software piracy (or in general copyright violation), we need to focus more closely on the specificities of the market that we are examining. In other words, one needs to take a closer look to the real markets instead of building a hypothetical model and come up with some conclusion. For that matter, before doing the actual research, an empirical investigation would be appropriate. Every market should be treated as a special case.

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