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Compensation for copying and bargaining

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Abstract

This paper investigates how hardware and/or blank media firms remunerate software publishers. If a software publisher is able to produce copy-protected software, the levy rate can be decided by negotiation between the software publisher and levy payers without the intervention of government. This paper examines conditions under which the remuneration scheme succeeds in compensating the software publisher for loss of profits due to copying.

JEL classification: L86; L13; O34
Keywords: Remuneration scheme; Copying; Compensation; Blank media; Bargaining

1. Introduction

Information goods are often illegally duplicated and distributed. In particular, digital content such as music CDs and computer software are reproduced and redistributed at very low cost. Publishers of information goods have asserted that illegal copying harms them by stealing their sales. According to a press release of the International Phonographic Industry Federation (April 7, 2004), world sales of recorded music fell in value by 7.6% in 2003 and they are in a four-year downturn. [1] However,

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[1] See http://www.ifpi.org/

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we cannot uncritically accept this assertion. Even if software were perfectly copy protected, all copy users would not necessarily become buyers of the original. As we see later, several researchers have pointed out that, in some situations, information goods publishers are able to appropriate the value that copy users place on these copies via pricing of the original (e.g., Leibowitz, 1985; Besen and Kirby, 1989; Varian, 2000).

If the information goods publishers cannot collect copy users' surplus, they would act to recoup the loss of profit from copying. One policy they use is to install protective devices that make copying the originals impossible into software program. For example, major record labels in Europe and Japan have begun to produce copy-protected CDs, the contents of which cannot be stored on CD-ROMs or copied to PC hard disks. Copy-protected software has also been introduced in the computer software industry (for example, *Microsoft Windows XP*, *Microsoft Office XP*, *Mathematica*). An alternative policy is to lobby for a remuneration scheme under which the government or the organization representing the interests of copyright owners collects the remuneration for private copying from the recording devices and/or blank media and distributes it to the copyright owners.

The Australian Copyright Council (2001) reported that at least 42 countries have a copying remuneration scheme. The survey also reported that remuneration is collected from both recording devices and blank media in 27 countries, and from blank media in 15 countries. For example, in the United States, Congress passed the Audio Home Recording Act of 1992, which requires manufacturers or importers of digital audio recorders and blank media to pay royalties to the United States Copyright Office. The Alliance of Artists and Recording Companies distributes these royalties to recording artists and sound recording copyright owners. The levy on digital audio recorders is 2% of the wholesale price, with a floor of $1 royalty payment per recorder, and a ceiling of $8 per device (except for functionally integrated units containing more than one digital audio recorder, which have a $12 cap). The levy on blank media is 3% of the wholesale price. In Japan, since 1993, the Society for Administration of Remuneration for Audio Home Recording (SARAH) collects the remuneration from manufacturers and importers of digital recording machines and blank media and distributes it to copyright owners, performers and producers of the phonograms. SARAH decides the levy rate by agreement with manufactures and importers of digital recording machines and media. As a result of negotiations, the levy on digital recording machines is 2% of a portion of the standard price (65%) indicated on the catalog with a ceiling of ¥1000; the levy on digital recording media is 3% and the levy on digital video recording devices and digital video recording media is 1%.

Gayer and Shy (2003) analyzed a system in which the government imposes a tax on sales of hardware and distributes the tax revenue to the software publisher. They considered the situation where the software publisher decides the tax rate, and the hardware firm has no bargaining power. Therefore, the software publisher chooses a tax rate that maximizes its profit. However, since this unilaterally increases the hardware publisher's costs, it is doubtful that the hardware firm would accept this situation without government sanction.

This paper is an extension of Gayer and Shy in the sense that the remuneration levy can be imposed on blank media as well as on hardware. We show that, if the sum of the levy rate on hardware and blank media is constant, its distribution between them does not affect the profits of the software publisher, the hardware firm or the blank media firm. Therefore, they will bargain about the sum of the levy rate on hardware and blank media.

This paper investigates the bargaining problem where the software publisher and the organization representing the interests of the hardware firm and blank media firm bargain over (the sum of) the levy rate. Since profits of both the hardware firm and the blank media firm decrease with the levy rate, they have no incentive to come to the negotiating table. However, if the software publisher is able to produce copy-protected software, this option brings both hardware and blank media firms to the negotiating table. Using the Nash bargaining solution to analyze this situation, we show that, if the bargaining power of the software publisher is relatively large, the remuneration scheme can compensate the software publisher's copying loss. If its bargaining power is relatively small, the remuneration scheme fails to compensate fully. Furthermore, we find that, as the copy-protection cost is smaller, the remuneration scheme is more likely to fully compensate. This paper also provides welfare analysis of the remuneration scheme when the software publisher can eliminate copying. Although reducing the levy rate increases social welfare, too small a rate makes the software publisher adopt the copy-protection policy, worsening social welfare dramatically. Therefore, it could be that the levy rate that maximizes social welfare is positive.

There is an extensive literature on copyright protection of information goods. Novas and Waldman (1984) showed that an increase in copyright protection may decrease the welfare loss associated with underproduction of goods. Johnson (1985) demonstrated that the effect of copying on social welfare depends on the elasticity of supply and on the value that consumers place on product variety. Novos and Waldman, and Johnson assumed that copy users do not contribute to the original price. The model based on this assumption is referred to as the direct appropriability model. [2] Leibowitz (1985), Besen (1986), Besen and Kirby (1989), Varian (2000), King and Lampe (2003) and Kinokuni (2003) investigated when copying or sharing an original information good benefits the publisher, using the indirect appropriability model, in which publishers are able to appropriate the value that copy users place on these copies via pricing of the original. [3] The present paper, which examines the software publisher that can collect the remuneration from the hardware firm and/or the blank media firm, adopts the direct appropriability model.

The outline of the paper is as follows. Section 2 provides a basic model of a remuneration scheme when there is a software publisher, a hardware firm and a blank media firm. Section 3 examines the equilibrium of the price-setting game under the

[2] More recent studies using the direct appropriability model include Takeyama (1997) and Yoon (2002).

[3] Another line of research into copy protection is the analysis of the effects of copy protection on industries characterized by positive network externalities (see, for example, Conner and Rumelt, 1991; Takeyama, 1994; Shy and Thisse, 1999).

remuneration scheme. Section 4 investigates the levy rate bargaining game. Section 5 provides a welfare analysis. Section 6 presents our conclusions.

2. The model

Consider a market with a software publisher that produces a certain piece of software, [4] a hardware firm that produces devices for reproducing and playing or running the software, and a blank media firm that produces recordable blank media. There are potential software users who are uniformly distributed with density η ($\geqslant 1$) along the interval [0,1]. Each user consumes either zero or one unit of an original or a copy. Since software does not work without hardware, users of software (regardless of whether an original or its copy) have to purchase a piece of hardware. We assume that copy users have to purchase a piece of blank media on which to burn software or purchase a copy whose price equals the price of blank media.

Define the utility function of a user located at x ($0 \leqslant x \leqslant 1$) by:

$$U_x = \begin{cases} \alpha x - p_h - p_s & \text{if Option 1,} \\ \beta x - p_h - p_m & \text{if Option 2,} \\ 0 & \text{if Option 3.} \end{cases} \tag{1}$$

[Option 1] purchases hardware and an original of software and uses the original.
[Option 2] purchases hardware and blank media and uses the copy.
[Option 3] does not use any software.

Let p_s, p_h, p_m denote the price of software, hardware and blank media, respectively. The parameter α (>0) measures a user's basic utility from using the original of the software and the parameter β (>0) measures a user's basic utility from using the copy. Following Gayer and Shy (2003), we make the following assumption:

$$\alpha > \beta. \tag{2}$$

Assumption (2) means that the original and the copy are vertically differentiated. For example, copy users may not get the record jackets, software manuals, upgrades or supporting services, or may have a troubled conscience.

We assume that the marginal cost of producing an original is larger than the marginal cost of copying. This assumption guarantees that there exist copies in equilibrium even if the network effect is small. [5] Let c (>0) denote the marginal cost of producing an original. With no loss of generality, we assume that there are no production costs except for the marginal cost of producing an original.

[4] For example, software includes music, movies, computer software and digitally stored books.

[5] For simplicity, this paper's model does not include network externalities. Therefore, the model can apply to the recording and video movie industries in which network externalities do not matter. Incorporating network externalities into the model does not essentially alter our conclusion.

We add the following assumption:

$$\frac{\alpha-\beta}{2} < c < \frac{3\alpha(\alpha-\beta)(4\alpha+\beta)}{(4\alpha-\beta)(3\alpha+\beta)}. \tag{3}$$

Assumption (3) guarantees that there exist both original users and copy users even when the remuneration levy rate is sufficiently high. [6] Assumption (3) also guarantees that there exist equilibria without copying.

Let x_c denote the type of consumers who are indifferent between using a copy of the software and not using the software at all. From (1), we have:

$$x_c = \frac{p_h + p_m}{\beta}. \tag{4}$$

Letting x_b denote the type of consumers who are indifferent between buying the original and using the copy, we obtain:

$$x_b = \frac{p_s - p_m}{\alpha - \beta}. \tag{5}$$

The demand the hardware firm faces is:

$$D_h(p_h,p_m) = \eta(1 - x_c) = \frac{\eta(\beta - p_h - p_m)}{\beta}. \tag{6}$$

The hardware demand function (6) means that hardware is a complement of blank media. The demand the software publisher faces is:

$$D_s(p_s,p_m) = \eta(1 - x_b) = \eta\left(1 - \frac{p_s - p_m}{\alpha - \beta}\right). \tag{7}$$

The software demand function (7) means that software is a substitute of blank media. The demand the blank media firm faces is:

$$D_m(p_s,p_h,p_m) = D_h(p_h,p_m) - D_s(p_s,p_m). \tag{8}$$

The blank media demand function (8) means that blank media is a substitute of software and a complement of hardware.

3. Levying hardware and blank media

In Gayer and Shy (2003), the government imposes the tax on the hardware firm and distributes it to the software publisher. Our model differs from Gayer and Shy in two ways. First, we assume that the software publisher asks for remuneration from the hardware firm and/or the blank media firm. In practice, countries that adopt a remuneration scheme require payment from both hardware firms and blank

[6] In the levy rate bargaining game, the levy rate that maximizes the software publisher's profit is chosen when the software publisher has all the bargaining power. In this case, if the marginal cost of producing an original is too low, copying is eliminated, and if too high, the software will not be produced.

media firms or only from blank media firms. Second, we assume that the software publisher collects remuneration directly from the hardware firm and/or the blank media firm, and not by taxation. This assumption is required to investigate how the levy rate may be determined without intervention by government. Even if the levy rate is specified in the legislation, leviers and levy payers usually negotiate over the levy rate before it is chosen.

The game consists of two stages: In the first stage, bargaining over the levy rate takes place between firms. Details of the bargaining game will be shown in Section 4. In the second stage, each firm simultaneously chooses its price given the levy rate agreed in the first stage. We begin by examining the second stage of the game. Letting t_h denote the per-unit levy on hardware and t_m denote the per-unit levy on blank media, the software publisher's profit is:

$$\pi_s = D_s(p_s,p_m)(p_s - c) + t_h D_h(p_h,p_m) + t_m D_m(p_s,p_h,p_m), \tag{9}$$

the hardware firm's profit is:

$$\pi_h = (p_h - t_h)D_h(p_h,p_m) \tag{10}$$

and the blank media firm's profit is:

$$\pi_m = (p_m - t_m)D_m(p_s,p_h,p_m). \tag{11}$$

Given the levy rates, the first-order condition for profit maximization of each firm is, respectively:

$$\frac{\partial \pi_s}{\partial p_s} = D_s(p_s,p_m) + \frac{\partial D_s(p_s,p_m)}{\partial p_s}(p_s - c) + t_m \frac{\partial D_m(p_m,p_s,p_h)}{\partial p_s} = 0, \tag{12}$$

$$\frac{\partial \pi_h}{\partial p_h} = D_h(p_h,p_m) + \frac{\partial D_h(p_h,p_m)}{\partial p_h}(p_h - t_h) = 0, \tag{13}$$

$$\frac{\partial \pi_m}{\partial p_m} = D_m(p_m,p_s,p_h) + \frac{\partial D_m(p_m,p_s,p_h)}{\partial p_m}(p_m - t_m) = 0. \tag{14}$$

From (12)–(14), it follows that each firm's reaction function is:

$$p_s(p_m;t_m) = \frac{1}{2}(\alpha - \beta + c + t_m + p_m), \tag{15}$$

$$p_h(p_m;t_h) = \frac{1}{2}(\beta + t_h - p_m), \tag{16}$$

$$p_m(p_s,p_h;t_m) = \frac{1}{2\alpha}(\alpha t_m + \beta p_s - (\alpha - \beta)p_h). \tag{17}$$

The solutions of Eqs. (15)–(17) are:

$$\hat{p}_s = \frac{3\alpha(\alpha - \beta) + (3\alpha + \beta)c - (\alpha - \beta)t_h + (5\alpha + \beta)t_m}{6\alpha}, \tag{18}$$

$$\hat{p}_h = \frac{3\alpha\beta - \beta c + (4\alpha - \beta)t_h - (2\alpha + \beta)t_m}{6\alpha}, \tag{19}$$

$$\hat{p}_m = \frac{\beta c - (\alpha - \beta)t_h + (2\alpha + \beta)t_m}{3\alpha}. \tag{20}$$

From (18)–(20), we have the following proposition.

Proposition 1. *An increase in the levy on hardware increases the price of hardware and decreases the prices of software and blank media. An increase in the levy on blank media increases the prices of blank media and software and decreases the price of hardware.*

We now examine the logic behind Proposition 1. The reaction function of the hardware firm (16) means that prices of hardware and blank media are strategic substitutes from the hardware firm's viewpoint in the sense of Bulow et al. (1985). Substituting (15) into (17) and rearranging, we obtain the price of the blank media as a function of the price of hardware:

$$p_{\mathrm{m}}(p_{\mathrm{h}}; t_{\mathrm{m}}) = \frac{1}{4\alpha - \beta}(\beta(\alpha - \beta + c) + (2\alpha + \beta)t_m - 2(\alpha - \beta)p_{\mathrm{h}}). \tag{21}$$

Function (21) states that prices of hardware and blank media are strategic substitutes from the blank media firm's viewpoint. An increase in the levy rate on hardware increases the marginal cost of providing hardware, increasing the price of hardware and decreasing the price of blank media (see Fig. 1). Since the reaction function (15) demonstrates that prices of software and blank media are strategic complements from the software publisher's viewpoint, a decrease in the price of blank media also decreases the price of software. An increase in the levy rate on blank media increases the marginal cost of providing blank media, increasing the price of blank media. This decreases the price of hardware since prices of hardware and blank media are strategic substitutes (see Fig. 2). From the reaction function (15), an increase in the price of blank media increases the price of software.

In the duopoly model of Gayer and Shy, there is no strategic interaction between software and hardware prices. The reason is as follows: Since both original users and copy users purchase hardware, changes of the hardware price do not affect the

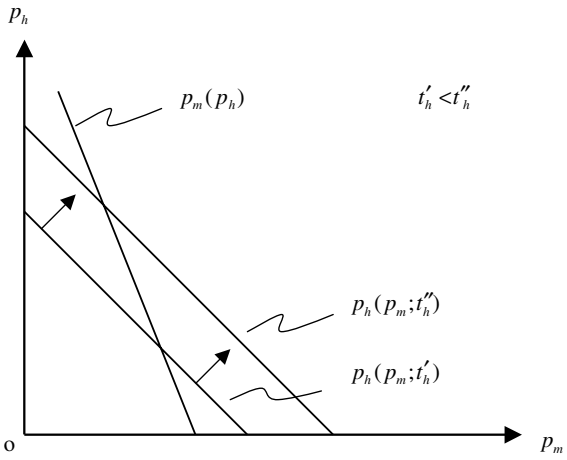

Fig. 1. Effect of the levy on hardware on reaction functions.

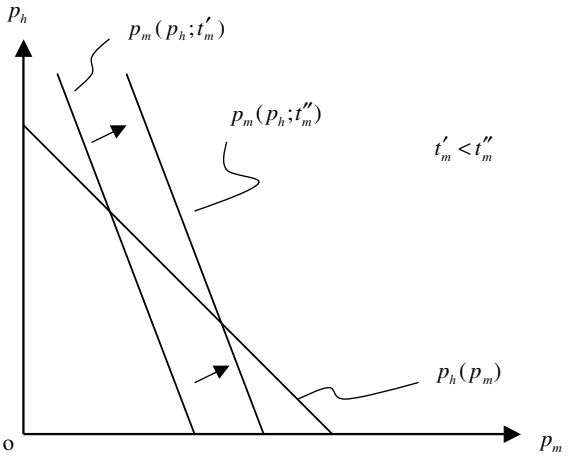

Fig. 2. Effect of the levy on blank media on reaction functions.

behavior of original buyers. Thus, the software price is chosen independently of the decision of the hardware price. On the contrary, this paper shows that there are strategic interactions among the price decisions of the three firms. The reason is as follows: An increase in the price of blank media raises the cost of using the copy, making using the original attractive. Thus, pricing of blank media affects the behavior of original buyers in addition to behaviors of blank media buyers and hardware buyers. The interaction between software and hardware prices occurs via pricing of blank media.

The following proposition examines the effects on payments by original and copy users of the levies on hardware and blank media.

Proposition 2. *An increase in the levy on hardware increases payments by both original and copy users. An increase in the levy on blank media also increases their payments.*

Proof. From (18)–(20), the effect of the levy on hardware on payments by original users and the effect of the levy on blank media on their payments are given by:

$$\frac{\partial}{\partial t_{\mathrm{h}}}(\hat{p}_{\mathrm{s}}+\hat{p}_{\mathrm{h}})=\frac{\partial}{\partial t_{\mathrm{m}}}(\hat{p}_{\mathrm{s}}+\hat{p}_{\mathrm{h}})=\frac{1}{2}>0.$$

The effect of the levy on hardware on payments by copy users and the effect of the levy on blank media on their payments are given by:

$$\frac{\partial}{\partial t_{\mathrm{h}}}(\hat{p}_{\mathrm{h}}+\hat{p}_{\mathrm{m}})=\frac{\partial}{\partial t_{\mathrm{m}}}(\hat{p}_{\mathrm{h}}+\hat{p}_{\mathrm{m}})=\frac{2\alpha+\beta}{6\alpha}>0. \qquad \square$$

Substituting (18)–(20) into (9)–(11) yields:

$$\pi_{\mathrm{h}}(\tau)=\frac{\eta\{3\alpha\beta-\beta c-(2\alpha+\beta)\tau\}^2}{36\alpha^2\beta}, \tag{22}$$

$$\pi_m(\tau) = \frac{\eta\{\beta c - (\alpha-\beta)\tau\}^2}{9\alpha\beta(\alpha-\beta)}, \tag{23}$$

$$\pi_s(\tau) = \frac{\eta\{6\alpha\beta(2\alpha+\beta) - 2\beta^2 c - (12\alpha^2 + 5\alpha\beta + \beta^2)\tau\}\tau}{36\alpha^2\beta} + \frac{\eta\{3\alpha(\alpha-\beta) - (3\alpha-\beta)c\}^2}{36\alpha^2(\alpha-\beta)}, \tag{24}$$

where τ is the sum of the levy rate on hardware and blank media, i.e., $\tau \equiv t_h + t_m$. From (22) and (23), we obtain the following proposition.

Proposition 3. *An increase in the sum of the levy rate on hardware and blank media decreases the profits of the hardware firm and the blank media firm.*

Proposition 3 states that an increase in a levy rate on hardware harms not only the hardware firm but also the blank media firm. Similarly, an increase in a levy rate on blank media harms not only the blank media firm but also the hardware firm. From Proposition 3, we have the following corollary.

Corollary 1. *If the sum of the levy rate on hardware and blank media is constant, the distribution between them does not affect the profits of either the hardware firm or the blank media firm.*

Now, consider the case where the software publisher produces copy-protected software, which eliminates copying. We assume that developing copy-protected software incurs an investment cost F, $0 \leqslant F \leqslant \eta(\alpha - c)^2/(9\alpha)$. Without copying, the demands the software publisher and the hardware firm face are:

$$D_s^0(p_s,p_h) = D_h^0(p_s,p_h) = \frac{\eta(\alpha - p_s - p_h)}{\alpha}.$$

The maximization problems for the software publisher and the hardware firm are, respectively:

$$\max_{p_s} \ \pi_s = D_s^0(p_s,p_h)(p_s - c) - F,$$

$$\max_{p_h} \ \pi_h = D_h^0(p_s,p_h)p_h.$$

The equilibrium prices of the hardware and the software are, respectively:

$$p_s^0 = \frac{\alpha + 2c}{3} \quad \text{and} \quad p_h^0 = \frac{\alpha - c}{3}.$$

Thus, when the software publisher produces copy-protected software, the equilibrium profits of the software and the hardware firms are, respectively:

$$\pi_s^0 = \frac{\eta(\alpha - c)^2}{9\alpha} - F, \quad \pi_h^0 = \frac{\eta(\alpha - c)^2}{9\alpha}. \tag{25}$$

Note that the profit of the blank media firm is zero without copying since the blank media are used only for copying software.

4. The bargaining stage

This section examines the first stage. We assume that, in the first stage, the software publisher and the organization that represents both the interests of the hardware firm and the blank media firm bargain over the levy rate. [7] The purpose of the organization is to maximize the aggregate profits of members through negotiations with the software publisher. Suppose that, if the software publisher and the organization disagree on the levy rate, the software publisher introduces copy-protected software when it finds that this option is more profitable than allowing copying. The software publisher's ability to eliminate copying brings the organization to the negotiating table since it harms both the hardware firm and the blank media firm in some cases. Thus, in the event of a breakdown of negotiations, the fallback payoffs of the software publisher and the hardware firm are π_s^0 and π_h^0, respectively. The fallback utility of the blank media firm is zero. We assume that forming the organization must satisfy participation constraints of both the hardware firm and the blank media firm, i.e., $\pi_h(\tau) \geqslant \pi_h^0$ and $\pi_m(\tau) \geqslant 0$. Since $D_h > D_m$, the participation constraint of the hardware firm is sufficient for the blank media firm to participate in the bargaining. Therefore, the fallback utility of the organization is $\pi_h^0(+0)$.

This situation is a typical bargaining problem. The outcome of the bargaining process is given by the asymmetric Nash bargaining solution (see Binmore et al., 1986; De Fraja, 1993). The Nash solution is given by solving the following maximization problem:

$$\max_{\tau \in \Psi} V = (\pi_s(\tau) - \pi_s^0)^{\theta} (\pi_h(\tau) + \pi_m(\tau) - \pi_h^0)^{1-\theta},$$

where $\Psi \in \{\tau : \pi_s(\tau) \geqslant \pi_s^0, \pi_h(\tau) \geqslant \pi_h^0\}$. The parameters θ $(0 \leqslant \theta \leqslant 1)$ and $(1-\theta)$ represent the software publisher's and the organization's bargaining power, respectively. The first-order condition of the maximization problem is:

$$\theta \frac{\pi_s'(\tau)}{\pi_s(\tau) - \pi_s^0} + (1-\theta) \frac{\pi_h'(\tau) + \pi_m'(\tau)}{\pi_h(\tau) + \pi_m(\tau) - \pi_h^0} = 0 \tag{26}$$

subject to $\pi_s(\tau) \geqslant \pi_s^0$ and $\pi_h(\tau) \geqslant \pi_h^0$. From the Nash theorem, condition (26) has a unique solution τ_a.

Let $\tau_{\min}$ denote the lower solution to $\pi_s(\tau) = \pi_s^0$ and $\tau_{\max}$ denote the lower solution to $\pi_h(\tau) = \pi_h^0$. Let τ^* denote the levy rate that maximizes the profit of the software publisher, i.e.,

$$\tau^* \equiv \arg\max_{\tau} \pi_s(\tau).$$

The organization never accepts a rate that is higher than $\tau_{\max}$ since it is better off breaking off the negotiations and gaining the profit without copying rather than accepting the rate. In addition, levy rates that are higher than τ^* are worse for both

[7] If the software publisher bargains separately with the hardware firm and the blank media firm, τ takes two values. By assuming that the hardware firm and the blank media firm constitute the organization, we obtain a unique solution.

the software publisher and the organization. Therefore, the agreed levy rate does not exceed $\min\{\tau^*,\tau_{\max}\}$. If $\tau_{\min} \geqslant 0$, the software publisher never accepts a rate that is lower than $\tau_{\min}$. If $\tau_{\min} < 0$, the software publisher gains more profits by allowing copying and not claiming remuneration rather than eliminating copying. Therefore, the agreed levy rate is not below $\max\{0,\tau_{\min}\}$. Thus, the agreed levy rate falls over the range $[\max\{0,\tau_{\min}\},\min\{\tau^*,\tau_{\max}\}]$. Fig. 3 shows τ^* and the lower bound of the levy rate (it is the case where $\tau_{\min} > 0$).

Below, we assume that the agreed levy rate is an interior solution, i.e., $\max\{0, \tau_{\min}\} < \tau_a < \min\{\tau^*,\tau_{\max}\}$. We check the relationship between bargaining power and the agreed levy rate. Define the left-hand side of Eq. (26) by $\chi(\tau)$. The effect of the software publisher's bargaining power on the agreed levy rate is given by

$$\frac{\mathrm{d}\tau_a}{\mathrm{d}\theta} = -\frac{\partial\chi(\tau_a)/\partial\theta}{\partial\chi(\tau_a)/\partial\tau}, \tag{27}$$

which is derived from condition (26). The second-order condition guarantees that $\partial\chi(\tau_a)/\partial\tau < 0$. Substituting $\partial\chi(\tau_a)/\partial\theta$ into condition (26) yields:

$$\theta\frac{\partial\chi(\tau_a)}{\partial\theta} + \frac{\pi'_{\mathrm{h}}(\tau_a) + \pi'_{\mathrm{m}}(\tau_a)}{\pi_{\mathrm{h}}(\tau_a) + \pi_{\mathrm{m}}(\tau_a) - \pi^0_{\mathrm{h}}} = 0. \tag{28}$$

It follows that $\partial\chi(\tau_a)/\partial\theta > 0$ since

$$\pi'_{\mathrm{h}}(\tau_a) = -\eta(2\alpha+\beta)\{\beta(3\alpha-c) - (2\alpha+\beta)\tau_a\}/(18\alpha^2\beta) < 0$$

and

$$\pi'_{\mathrm{m}}(\tau_a) = -2\eta(\beta c - (\alpha-\beta)\tau_a)/(9\alpha\beta) < 0.$$

Hence, we obtain $\mathrm{d}\tau_a/\mathrm{d}\theta > 0$, that is, the stronger the bargaining power of the software publisher, the higher is the agreed rate. When $\theta = 1$, the agreed rate is that which maximizes the profit of the software publisher under the condition where

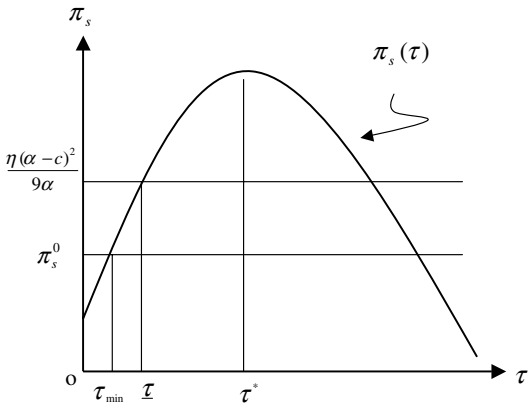

Fig. 3. Lower bound of the levy rate and the rate that maximizes the profit of the software publisher.

the organization does not turn down the remuneration scheme, i.e., $\tau_a = \min\{\tau^*, \tau_{\max}\}$. When $\theta = 0$, the agreed rate is that which maximizes the aggregate profits of the hardware firm and the blank media firm under the condition where the software publisher does not shift to the policy of eliminating copying from the remuneration scheme, i.e., $\tau_a = \max\{0, \tau_{\min}\}$.

Letting $\underline{\tau}$ denote the lower solution to $\pi_s(\tau) = \eta(\alpha - c)^2/(9\alpha)$, it just compensates the loss of profit of the software publisher from copying. Since $d\tau_{\min}/dF = -[\pi_s'(\tau_{\min})]^{-1} < 0$, we have $\underline{\tau} \geqslant \tau_{\min}$. When $F = 0$, $\underline{\tau} = \tau_{\min}$. Thus, we can state the following proposition.

Proposition 4. *When the bargaining power of the software publisher is relatively strong (resp. weak), the agreed levy rate is higher (resp. lower) than the rate that compensates just the loss of profit of the software publisher from copying.*

Even if the levy rate is lower than $\underline{\tau}$, the software publisher does not always take action to eliminate copying. Copy protection requires costs. If the levy rate is below $\tau_{\min}$, then and only then the software publisher is better off producing copy-protected software. The following proposition shows the effect of the cost of copy protection on the agreed levy rate.

Proposition 5. *The lower the copy-protection cost, the higher is the agreed levy rate, i.e.,* $d\tau_a/dF < 0$.

Proof. The effect of the copy-protection cost on the agreed levy rate is given by:

$$\frac{d\tau_a}{dF} = -\frac{\partial\chi(\tau_a)/\partial F}{\partial\chi(\tau_a)/\partial\tau}, \tag{29}$$

which is derived from condition (26). The second-order condition guarantees that $\partial\chi(\tau_a)/\partial\tau < 0$. Since $\pi_h'(\tau_a) + \pi_m'(\tau_a) < 0$, $\pi_s'(\tau_a) > 0$ from condition (26). Thus, we have:

$$\frac{\partial\chi(\tau_a)}{\partial F} = -\frac{\theta\pi_s'(\tau_a)}{(\pi_s(\tau_a) - \pi_s^0)^2} < 0. \tag{30}$$

From (29) and (30), it follows that $d\tau_a/dF < 0$. □

A decrease in the copy-protection cost increases the software publisher's profit under the copy-protection policy. That is, it increases the profits of the software publisher in the event of a breakdown of negotiation and enhances the software publisher's bargaining power, thus, increasing the agreed rate. That is, the smaller the copy-protection cost, the greater the software publisher's profits under the remuneration scheme. From Proposition 5, we have the following corollary.

Corollary 2. *The smaller is the copy-protection cost, the more likely the remuneration scheme is to compensate the loss of profit of the software publisher from copying.*

Table 1 presents a numerical example of the bargaining solution under the assumption that $\alpha = 100$, $\beta = 90$, $c = 10$. When $\tau_a > \underline{\tau}$, the agreement compensates the loss of profit of the software publisher from copying. This numerical example

Table 1
Numerical example of the bargaining solution

				θ										
				0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
	$\tau_{\min}$	$\underline{\tau}$	$\tau_{\max}$	τ_a										
$F=0$	25.8	25.8	31.1	25.8	**26.4**	**27.0**	**27.6**	**28.2**	**28.9**	**29.6**	**30.2**	**30.9**	**31.1**	**31.1**
$F=10$	21.3	25.8	31.1	21.3	22.4	23.4	24.4	25.4	**26.4**	**27.5**	**28.6**	**29.7**	**31.0**	**31.1**
$F=20$	17.6	25.8	31.1	17.6	19.0	20.2	21.6	22.9	24.2	25.6	**27.1**	**28.6**	**30.4**	**31.1**
$F=30$	14.4	25.8	31.1	14.4	16.0	17.5	19.1	20.7	22.3	24.0	**25.8**	**27.7**	**29.8**	**31.1**
$F=40$	11.4	25.8	31.1	11.4	13.2	15.1	16.9	18.7	20.6	22.5	24.6	**26.8**	**29.3**	**31.1**

shows that the stronger the bargaining power of the software publisher or the smaller the copy-protection cost, the better the remuneration scheme is for the publisher than without copying. For example, when $F = 10$, the remuneration scheme succeeds in compensating the software publisher for loss of profits due to copying if $\theta = 0.5$, and fails to compensate it if $\theta = 0.4$. However, when $F = 20$, $\theta = 0.5$ is insufficient to sustain the remuneration scheme.

5. Welfare analysis

This section explores the welfare implications of the remuneration scheme. First, consider the problem for the regulator of both the levy rate and the software publisher's copyright policy. Assume that social welfare is measured by the total surplus. In the remuneration scheme, social welfare is given by:

$$W(\tau) = \eta \int_{1-\hat{D}_s/\eta}^{1} (\alpha x - c)\, \mathrm{d}x + \eta \int_{1-\hat{D}_h/\eta}^{1-\hat{D}_s/\eta} \beta x\, \mathrm{d}x,$$

where

$$\hat{D}_s \equiv D_s(\hat{p}_s, \hat{p}_m) = \frac{\eta\{3\alpha(\alpha-\beta) - (3\alpha-\beta)c - (\alpha-\beta)\tau\}}{6\alpha(\alpha-\beta)},$$

$$\hat{D}_h \equiv D_h(\hat{p}_h, \hat{p}_m) = \frac{\eta\{3\alpha\beta - \beta c - (2\alpha+\beta)\tau\}}{6\alpha\beta}.$$

Differentiating social welfare with respect to the levy rate yields:

$$W''(\tau) = -\frac{\eta(4\alpha+5\beta)}{18\alpha\beta} < 0 \quad \text{and} \quad W'(0) = -\frac{\eta(9\alpha - \mathrm{c})}{18\alpha} < 0.$$

Thus, we obtain $W'(\tau) < 0$ for $\tau \geqslant 0$. The following proposition coincides with the result of Gayer and Shy.

Proposition 6. *Suppose that the regulator can control both the levy rate and the software publisher's copyright policy. The levy rate that maximizes social welfare is then zero.*

Next, consider the regulator who can choose the levy rate that maximizes social welfare but is unable to prohibit the software publisher from producing copy-protected software. In the copy-protection case, social welfare is:

$$W^{\mathrm{CP}} = \eta \int_{1-\hat{D}_{\mathrm{s}}^{0}/\eta}^{1} \alpha x \, \mathrm{d}x - F = \frac{5\eta(\alpha - c)^2}{18\alpha} - F,$$

where $\hat{D}_{\mathrm{s}}^{0} \equiv D_{\mathrm{s}}^{0}(p_{\mathrm{s}}^{0}, p_{\mathrm{h}}^{0}) = \eta(\alpha - c)/(3\alpha)$. The following proposition examines the problem for the regulator when the software publisher can produce copy-protected software.

Proposition 7. *Suppose that the regulator can choose the levy rate that maximizes social welfare but is unable to prohibit the software publisher from producing copy-protected software. The levy rate that maximizes social welfare may be positive.*

Proof. Since $W'(\tau) < 0$ for $\tau \geqslant 0$, the lower is τ, the higher is social welfare. Recall that the software publisher produces copy-protected software if $\tau < \tau_{\min}$. Thus, if $\tau_{\min} \leqslant 0$, the software publisher never produces copy-protected software and the levy rate that maximizes social welfare is zero since

$$W(0) - W^{\mathrm{CP}} = \frac{\eta[7\alpha^2(\alpha - \beta) - c\{14\alpha(\alpha - \beta) - c(7\alpha + 13\beta)\}]}{72\alpha(\alpha - \beta)},$$

which is positive under assumption (3). If $\tau_{\min} > 0$, the rate $\tau_{\min}$, which makes the software publisher indifferent between keeping the remuneration scheme and eliminating copying, maximizes social welfare as long as $W(\tau_{\min}) \geqslant W^{\mathrm{CP}}$. □

The lower the levy rate, the higher is social welfare. However, if the levy rate is too low for the software publisher, the software publisher adopts the policy that eliminates copying. The regulator has to choose the levy rate taking the software publisher's reaction into consideration.

6. Conclusion

In 2003, Gayer and Shy made the first attempt to conduct a theoretical analysis of remuneration schemes. They investigated a duopoly model with a software publisher and a hardware firm that pays the levy. We have considered an economy with a blank media firm as well as a software publisher and a hardware firm and have found that price decisions of the three firms are conditioned by strategic relationships. An increase in the levy on hardware increases both payments by original users and copy users. This effect reduces both sales of hardware and blank media, decreasing the profits of the hardware firm and the blank media firm. Changes of the levy on blank media also have the same effect as changes of the levy on hardware. Thus, if the sum of the levy rate on hardware and blank media is constant, the distribution between them does not affect the profits of the hardware firm or the blank media firm.

Our main contribution is to investigate the bargaining game where the software publisher and the levy payers bargain over the levy rate. Since profits of both the

hardware firm and the blank media firm decrease with the levy rate, they have no incentive to participate in bargaining. However, if the software publisher is able to produce copy-protected software, this brings the hardware firm and the blank media firm to the negotiating table. If the bargaining power of the software publisher is relatively great, the software publisher gains more profit under the remuneration scheme than without copying. If it is relatively small, the remuneration scheme fails to compensate the software publisher's loss of profit from copying. We have also examined the welfare implications of the remuneration scheme. Welfare is decreasing in the levy rate. However, if the levy rate is too small, the software publisher is better off producing copy-protected software rather than using the remuneration scheme. Therefore, in some cases, setting the levy rate that makes the software publisher indifferent between keeping the remuneration scheme and producing copy-protected software maximizes social welfare.

In the world in which we live, it would seem that software publishers have no confidence in remuneration schemes. As an illustration, the record industry has countered piracy by introducing copy-protected CDs despite the existence of remuneration schemes. We have pointed out that the software publisher can profit by the remuneration scheme more than by copy protection. There are at least two reasons why remuneration schemes do not work well enough. First, the bargaining power of software publishers is too weak and thus the levy rate is too small to recoup their losses. Second, although for simplicity we have not considered this in the model, negotiations over the levy rate involve large transaction costs and thus software publishers prefer to invest in copy-protection technology rather than bargain over the levy rate.

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