Who Should Bell Piracy?
An Experimental Analysis.

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Abstract:

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1. Introduction

The growing concern regarding the sale of illegitimate copies of software, music and movie cds and dvds and its widespread impact on such industries have taken the centre stage in recent years. Such concerns have prompted extensive discussions and debates on measures to curb piracy that mainly focus on implementation of anti-copying technology and enforcement policies.

In a recent paper, Banerjee et.al. (2008) have discussed the mix of anti-copying technology and enforcement measures in the form of monitoring and penalizing the seller of illegitimate copies, hereafter to as the pirate, to counter commercial or retail piracy. They show that if no monitoring is socially optimal then the equilibrium level of anti-copying investment may prevent piracy. If monitoring is socially optimal then the equilibrium level of anti-copying investment is not fully successful in preventing piracy. But the question remains as to whether the anti-piracy efforts lay solely on the government's enforcement policies or solely on the individual firm's investment on anti-copying technology or is it a mix of both? To the best of our knowledge this issue which is yet to be addressed in the literature is the main focus of this paper.

In this paper we a legitimate firm referred to as the monopolist, a pirate who sells illegitimate copies of the monopolist's product and a government who is responsible for the enforcement of anti-piracy efforts by monitoring and penalizing the pirate. We consider a sequential entry-deterrence framework in which the monopolist's output strategy either allows or deters the pirate's entry. In the absence of investment on anti-copying technology by the monopolist no monitoring is socially optimal and there is piracy in equilibrium.

Introduction of the investment in anti-copying technology yields the following interesting results. The socially optimal monitoring rate deters piracy and restores the monopoly outcome. Consequently, there is no anti-copying investment in equilibrium. This result is opposite to that in Banerjee et.al.(2007). This happens when the monitoring cost is relatively small compared to the anti-copying investment. Only if the monitoring cost is "sufficiently" high then there is a positive level of anti-copying investment but it is not sufficient to prevent piracy with certainty.

These findings have important policy implications. Countries where monitoring is relatively inefficient in the sense that monitoring is costly may be due to leakages like corruption in the system should pursue anti-piracy measures through high level of investment in anti-copying investment at the firm level. Countries where monitoring is efficient should pursue anti-piracy efforts through government enforcement policies only without taking resort to any investment on anti-copying technology.

The intuition behind the last result is as follows. We show that the equilibrium anti-copying investment is inversely related to the monitoring rate. Both these costs are deadweight losses in the social welfare function. If monitoring is "sufficiently" less costly then the increase in the monitoring cost due to an increase in the monitoring rate is less than the decrease in the cost of investment on anti-copying technology. Therefore, it is optimal for the government to choose the maximum possible monitoring rate that restores the monopoly outcome such that there is no investment in anti-copying technology in equilibrium.

There is no available data on retail piracy, anti-copying investments, and government's enforcement policy to substantiate our claim empirically. We therefore

perform an experimental analysis which will provide us with the data required for the empirical analysis.

2. The Model

We consider the market for a product like software which can be copied by a fake producer hereafter referred to as the *pirate,* and illegally sold in the market thereby competing with the legitimate product, the producer of which is hereafter referred to as the *monopolist*. The market demand for this product is characterized by linear demand curve of the form, $p(q) = a - q$, where q and p denote the quantity and the price. For computational purposes we assume $a = 4$. We assume an installed monopolist which allows us to avoid the fixed cost of developing the product, and the marginal cost of production is assumed to be zero. The monopoly results in the absence of copying are $p_m^* = 2$, $q_m^* = 2$, and $\pi_m^* = 4$.

Let us now introduce copying our model. The pirate makes unauthorized copies of the monopolist's product and illegally sells it in the market. In the basic model the government is responsible for monitoring and penalizing the pirate which constitutes the enforcement policy. The monopolist can only prevent the pirate's entry through his output strategy as explained below. Let α be the monitoring rate and $c(\alpha)$ be the cost of monitoring with the properties $c'(\alpha) > 0$ and $c''(\alpha) > 0$. The monitoring cost is assumed to take the functional form $c(\alpha) = \dfrac{\alpha^2}{2}$. If the pirate's illegal activities are detected which occurs with probability α then he pays the penalty G, which is assumed to be given institutionally, to the government. The rationale behind this assumption is that this transfer compensates the government for bearing the monitoring cost and to avoid any other distributional issues.

The monopolist chooses a quantity strategy that either allows or deters the pirate's entry. The quantity strategy that allows the pirate's entry is referred to as the *accommodating strategy* (ac-strategy). In this case the monopolist chooses the profit maximizing output assuming that the pirate will enter the market. The quantity strategy that deters the pirate's entry, which is referred to as the *aggressive strategy* (ag-strategy), is the equilibrium limit quantity such that it is not profitable for the pirate to enter the market. The government chooses the social welfare maximizing monitoring rate. Social welfare is defined below. The game played between the government, the monopolist and the pirate can be represented in an extensive form as follows.

Stage 1: The government chooses a monitoring rate, α.

Stage 2: The monopolist either chooses an ac-strategy or an ag-strategy. Let q_m denote the monopolist's output.

Stage 3: The pirate makes his entry decision and chooses quantity q_p.

Table 1 summarizes the different events and the corresponding market demands, monopolist's profit and pirate's profit.

TABLE 1

Events	Market Demand	Monopolist's Profit	Fake-producer's Profit
Pirate enters and is detected with probability α	$p = 4 - q_m$ because $q_f = 0$.	$4q_m - q_m^2$	$-G$
Pirate do not enter	$p = 4 - q_m$ because $q_f = 0$.	$4q_m - q_m^2$	0
Pirate enters and is not detected with probability $(1-\alpha)$	$p = 4 - q_m - q_p$	$4q_m - q_m^2 - q_m q_p$	$4q_p - q_p^2 - q_m q_p$

Using Table 1 we get the monopolist's and the pirate's profit functions (if the latter decides to enter), π_m and π_p as follows.

$$\pi_m(q_m, q_f; \alpha) = (1-\alpha)(4q_m - q_m^2 - q_m q_p) + (1-\alpha)(4q_m - q_m^2),$$
$$\pi_p(q_m, q_f; \alpha) = (1-\alpha)(4q_p - q_p^2 - q_m q_p) - \alpha G. \tag{1}$$

Let π_m^i and π_p^i denote the monopolist's and the fake producer's expected profits for the monopolist's i-strategy, $i \in \{ac, ag\}$. We assume that the pirate enters only if he makes positive profit, that is only if $\pi_p > 0$.

Let q_m^{i*} denote the equilibrium i-strategy, $i \in \{ac, ag\}$ and π_m^{i*}, q_p^{i*}, π_p^{i*}, CS^i, and $SW^i = \pi_m^{i*} + \pi_p^{i*} + CS^{i*} + \alpha G - c(\alpha)$ be the corresponding monopolist's equilibrium profit, pirate's equilibrium output, pirate's equilibrium profit, consumer surplus and social welfare function which is the surplus of all the agents in the model. We first state the results for the ac-strategy and then that for the ag-strategy. The comparative static results for the monopolists equilibrium profits for the two strategies with respect to the monitoring rate and the social welfare maximizing results are stated in Proposition 1.

The first order conditions yield the equilibrium ac-strategy to be $q_m^{ac*} = 2$. The pirate's equilibrium output and profit is $q_p^{ac*} = 1$ and $\pi_p^{ac*} = 1 - 3\alpha$. The pirate's profit is monotonically decreasing in the monitoring rate and he cannot enter if

$\alpha \geq \alpha_{max} = \dfrac{1}{3}$. So for $\alpha \geq \alpha_{max}$ the monopoly results hold. The monopolist's profit, consumer surplus and social welfare for the equilibrium ac-strategy are as follows.

$$\pi_m^{ac*}(\alpha) = \begin{cases} 2(1+\alpha), & \text{for } \alpha \leq \alpha_{max} \\ 4, & \text{for } \alpha \geq \alpha_{max} \end{cases} \tag{2}$$

$$CS^{ac}(\alpha) = \begin{cases} \dfrac{9-5\alpha}{2}, & for\ \alpha \le \alpha_{max} \\ 2, & for\ \alpha \ge \alpha_{max} \end{cases} \tag{3}$$

$$SW^{ac}(\alpha) = \begin{cases} \dfrac{15-3\alpha-\alpha^2}{2}, & for\ \alpha \le \alpha_{max} \\ 6-\dfrac{\alpha^2}{2}, & for\ \alpha \ge \alpha_{max}. \end{cases} \tag{4}$$

The consumer surplus is determined as follows. If the pirate is not detected which occurs with probability $(1-\alpha)$ then the market output is 3 and the consumer surplus is $\dfrac{9}{2}$. Alternatively, if piracy is detected which occurs with probability α the market output is 4 and the corresponding consumer surplus is 2. The monopolist's profit is linearly increasing in the monitoring rate till $\alpha = \alpha_{max}$ at which the monopoly results hold.

Let us now analyze the ag-strategy which is the limit output strategy such that it is not profitable for the pirate to enter the market. From equation (1) the pirate's reaction function is $q_p = \dfrac{4-q_m}{2}$. Substituting this in the pirate's expected profit and equating it to zero yields the equilibrium ag-strategy which is

$$q_m^{ag*}(\alpha) = \begin{cases} 4-2\sqrt{\dfrac{2\alpha}{1-\alpha}}, & for\ \alpha \le \alpha_{max}, \\ 2, & for\ \alpha \ge \alpha_{max}. \end{cases}$$. The intuition for this result is as follows.

$4-2\sqrt{\dfrac{2\alpha}{1-\alpha}}$ is decreasing α. An increase in the monitoring rate decreases

$q_m^{ag*}(\alpha) = 4-2\sqrt{\dfrac{2\alpha}{1-\alpha}}$. At $\alpha = \alpha_{max} = \dfrac{1}{3}$, $q_m^{ag*}(\alpha) = 2$ which is the monopoly output level. So for $\alpha \ge \alpha_{max}$ the equilibrium ag-strategy remains at $q_m^{ag*}(\alpha) = 2$. The monopolist's profit, consumer surplus and the social welfare function for the equilibrium strategy are as follows.

$$\pi_m^{ag*}(\alpha) = \begin{cases} \left(4 - 2\sqrt{\dfrac{2\alpha}{1-\alpha}}\right) 2\sqrt{\dfrac{2\alpha}{1-\alpha}}, & \textit{for } \alpha \le \alpha_{max} \\ 4, & \textit{for } \alpha \ge \alpha_{max} \end{cases} \qquad (5)$$

$$CS^{ag}(\alpha) = \begin{cases} \dfrac{1}{2}\left(4 - 2\sqrt{\dfrac{2\alpha}{1-\alpha}}\right)^2, & \textit{for } \alpha \le \alpha_{max} \\ 2, & \textit{for } \alpha \ge \alpha_{max} \end{cases} \qquad (6)$$

$$SW^{ag}(\alpha) = \begin{cases} 4\left(4 - \sqrt{\dfrac{2\alpha}{1-\alpha}}\right) - \dfrac{1}{2}\left(4 - \sqrt{\dfrac{2\alpha}{1-\alpha}}\right)^2 - \dfrac{\alpha^2}{2}, & \textit{for } \alpha \le \alpha_{max} \\ 6 - \dfrac{\alpha^2}{2}, & \textit{for } \alpha \ge \alpha_{max} \end{cases} \qquad (7)$$

At $\alpha = 0$, the market becomes contestable because $q_m^{ag*}(\alpha = 0) = 4$ is the perfectly competitive outcome since the marginal cost is 0. Hence, at $\alpha = 0$, $\pi_m^{ag*}(\alpha = 0) = 0$. So the profit for the equilibrium ag-strategy is increasing in the monitoring rate and reaches its maximal value which is the monopoly profit level at $\alpha = \alpha_{max} = \dfrac{1}{3}$. The second order derivative of $\pi_m^{ag*}(\alpha)$ with respect to α is negative implying that $\pi_m^{ag*}(\alpha)$ is increasing and concave in α.

The comparison of the properties of $\pi_m^{ac*}(\alpha)$ and $\pi_m^{ag*}(\alpha)$ with respect to α is stated Lemma 1 and is diagrammatically shown in Figure 1. This comparison of the comparative static analysis of the two equilibrium profit functions with respect to α will be used to determine the social welfare maximizing monitoring rate.

Lemma 1: *In the range* $\alpha \in [0, \alpha_{max}]$ $\pi_m^{ac*}(\alpha)$ *and* $\pi_m^{ag*}(\alpha)$ *intersect at* α_1 *and* α_{max} *where* $0 < \alpha_1 < \alpha_{max}$

The intuitive proof of Lemma 1 is as follows. Since $\pi_m^{ac*}(\alpha = 0) = 2$ and $\pi_m^{ag*}(\alpha = 0)$ and the monopoly result for both strategies are restored at $\alpha = \alpha_{max} = \dfrac{1}{3}$, there exists

an $\alpha = \alpha_1$ where $0 < \alpha_1 < \alpha_{\max}$ at which $\pi_m^{ac*}(\alpha_1) = \pi_m^{ag*}(\alpha_1)$. This implies that

$\pi_m^{ac*}(\alpha) > \pi_m^{ag*}(\alpha)$ in the range $0 \le \alpha < \alpha_1$, and therefore the ac-strategy is dominant

in this range of the monitoring rate. $\pi_m^{ag*}(\alpha) \ge \pi_m^{ac*}(\alpha)$ in the range $\alpha_1 \le \alpha \le \alpha_{\max}$

and therefore, the ag-strategy is weakly dominant in this range of the monitoring rate.

This further implies that $SW^{ac}(\alpha)$ and $SW^{ag}(\alpha)$ are the relevant social welfare

functions to be considered in the ranges $0 \le \alpha \le \alpha_1$ and $\alpha_1 < \alpha \le \alpha_{\max}$.
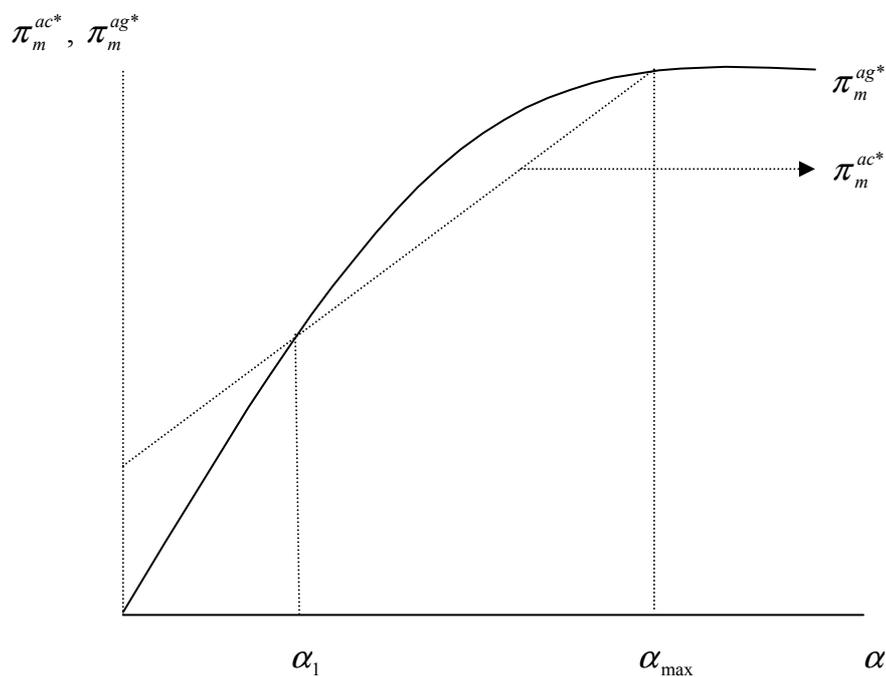
Figure 1: Comparison of the comparative static analysis of $\pi_m^{ac*}(\alpha)$ and $\pi_m^{ag*}(\alpha)$

In the range $0 \le \alpha \le \alpha_1$, $SW^{ac}(\alpha)$ is decreasing in α because

$SW^{ac'}(\alpha) = \dfrac{-3 - 2\alpha}{2} < 0$. Hence, $\alpha^{ac*} = 0$ maximizes $SW^{ac}(\alpha)$. In the range

$\alpha_1 < \alpha \le \alpha_{\max}$, $SW^{ag}(\alpha)$ is decreasing in α because $SW^{ag'}(\alpha) < 0$. Hence $\alpha^{ag*} = 0$

maximizes $SW^{ag}(\alpha)$. Proposition 1 summarizes he social welfare maximizing

monitoring rate denoted as α^*.

Proposition 1: *(i) The social welfare monitoring rate is $\alpha^* = \alpha^{ac*} = 0$ if*

$SW^{ac}(\alpha^{ac*} = 0) \geq SW^{ag}(\alpha^{ag*} = \alpha_1)$. *In this case the ac-strategy is the subgame*

perfect equilibrium and there is piracy in equilibrium. (ii) The social welfare

monitoring rate is $\alpha^* = \alpha^{ag*} = \alpha_1$ if $SW^{ac}(\alpha^{ac*} = 0) < SW^{ag}(\alpha^{ag*} = \alpha_1)$. In this case

the ag-staretgy is the subgame perfect equilibrium and piracy is deterred in

equilibrium.

3. Anti-copying investment

In the previous section we considered the case that any anti-copying measures were taken by the government only in the form of enforcement policies and the monopolist's pricing strategy may or may allow the pirate's entry. In this section we consider the case that along with the government's enforcement policies against piracy the monopolist also actively participates in anti-piracy measures by making an anti-copying investment that may reduce the possibility of copying. In stage 2 of the extensive form game mentioned in the previous section the monopolist chooses a level of anti-copying investment T along with the choice of accommodating or aggressive strategies.

Let $H(T)$ be the *probability that the pirate cannot copy* when the anti-copying investment is T. $H'(T) > 0$ and to satisfy the second order conditions we assume that $H''(T) < 0$, that is, $H(T)$ is increasing in T at a decreasing rate. For computational simplicity we assume the functional form $H(T) = \sqrt{T}$. At $T = 0$, $H(T) = 0$, that is copying always takes place and at $T = 1$, $H(T) = 1$ which implies that copying is prevented with certainty. So we assume that $T \in [0,1]$. Equation (8) states the possible events and the corresponding probabilities

Probability that the fake producer copies and is detected $= \alpha(1 - H(T))$,

Probability that the fake producer copies and is not detected $= (1 - \alpha)(1 - H(T))$, (8)

Probability that the fake producer cannot copy $= H(T)$.

Table 1 summarizes the market demand, the monopolist's and the fake-producer's

profits for each of the events described in equation (8).

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TABLE 2: COPYING, DETECTION, DEMAND AND PROFITS

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Events	Market Demand	Monopolist's Profit	Pirate's Profit
Fake-producer copies and is detected. Probability of this event is $\alpha(1 - H(T))$	$p = 4 - q_m$ because $q_p = 0$.	$4q_m - q_m^2 - T$	$-G$
Fake-producer cannot copy. Probability of this event is *H(T)*	$p = 4 - q_m$ because $q_p = 0$.	$4q_m - q_m^2 - T$	0
Fake-producer copies and is not detected. Probability of this event is $(1 - \alpha)(1 - H(T))$	$p = 4 - q_m - q_p$	$4q_m - q_m^2 - q_m q_p - T$	$4q_p - q_p^2 - q_m q_p$

Using Table 1 and the probability of the occurrences of the different events

described in equation (1) we get the monopolist's profit function π_m as follows.

$$\pi_m(q_m, q_p, T, \alpha) = (1 - \alpha)(1 - H(T))(4q_m - q_m^2 - q_m q_f - T)$$
$$+ (H(T) + \alpha(1 - H(T)))(4q_m - q_m^2 - T) \tag{9}$$

Let π_{ma}^i and π_{pa}^i denote the monopolist's and the fake producer's profit for the

monopolist's i-strategy, $i \in \{ac, ag\}$ when there is anti-copying investment which is

represented by '*a*' in the subscript. The pirate's's expected profit if he copies the

monopolist's product, which occurs with probability $1 - H(T)$, is

$$\pi_p(q_m, q_f, T, \alpha) = (1 - H(T))((1 - \alpha)(4q_p - q_p^2 - q_m q_p) - \alpha G). \tag{10}$$

The pirate's reaction function remains as $q_p = \dfrac{4 - q_m}{2}$.

We begin our analysis with the equilibrium ac-strategy. Substituting the pirate's reaction function in the monopolist's expected profit function and maximizing it with respect to q_m and T yields $q_{ma}^{ac*} = 2$ and $T^{ac*} = (1-\alpha)^2$. The pirate's equilibrium quantity if he enters is $q_{pa}^{ac*} = 1$. The pirate's expected equilibrium profit is

$\pi_{pa}^{ac*}(\alpha) = (1 - H(T^{ac*}))(1 - 3\alpha)$. The pirate cannot enter if either $H(T^{ac*}) = 1$ or

$\alpha = \alpha_{max} = \dfrac{1}{3}$. If $\alpha \geq \alpha_{max} = \dfrac{1}{3}$ then the pirate cannot enter even if he can copy. So for

$\alpha \geq \alpha_{max} = \dfrac{1}{3}$ the equilibrium anti-copying investment is $T^{ac*} = 0$. So the complete

characterisation of the equilibrium anti-copying investment and the monopolist's and pirate's profit are as follows.

$$T^{ac*} = \begin{cases} (1-\alpha)^2, & if\ \alpha < \alpha_{max} \\ 0, & if\ \alpha \geq \alpha_{max}. \end{cases} \tag{11}$$

$$\pi_{ma}^{ac*}(\alpha) = \begin{cases} 3 + \alpha^2, & if\ 0 \leq \alpha < \alpha_{max}, \\ 4, & at\ \alpha = \alpha_{max}. \end{cases} \tag{12}$$

$$\pi_{pa}^{ac*}(\alpha) = \begin{cases} \alpha(1 - 3\alpha), & if\ 0 \leq \alpha < \alpha_{max}, \\ 0, & at\ \alpha = \alpha_{max}. \end{cases}$$

$T^{ac*} = (1-\alpha)^2$ is decreasing in the monitoring rate till $\alpha < \alpha_{max} = \dfrac{1}{3}$. If $\alpha = 0$ then

$T^{ac*} = 1$ and copying is prevented with certainty in which case the monopoly profit net of the anti-copying investment holds, that is, $\pi_{ma}^{ac*}(\alpha) = 3$. The monopolist's profit is increasing at an increasing rate till $\alpha < \alpha_{max} = \dfrac{1}{3}$. For $\alpha \geq \alpha_{max}$ the monopoly results are restored.

Table 3 summarizes the events and the corresponding equilibrium profits, consumer surplus, government's expected net revenue the sum of which yields the social welfare function.

TABLE 3: EVENTS AND REALIZED EQUILIBRIUM PAYOFFS

| Events / Realized Equilibrium Payoffs	Fake-producer cannot copy. Probability of this event is $H(T^{ac*})$	Fake-producer copies and is detected. Probability of this event is $\alpha(1-H(T^{ac*}))$	Fake-producer copies and is not detected. Probability of this event is $(1-\alpha)(1-H(T^{ac*}))$
π_{ma}^{ac*}	$4-T^{ac*}$	$4-T^{ac*}$	$2-T^{ac*}$
π_{pa}^{ac*}	0	-2	1
CS_a^{ac}	2	2	4.5
Govt. Revenue	$-\dfrac{\alpha^2}{2}$	$2-\dfrac{\alpha^2}{2}$	$-\dfrac{\alpha^2}{2}$
SW_a^{ac}	$6-\dfrac{\alpha^2}{2}-T^{ac*}$	$6-\dfrac{\alpha^2}{2}-T^{ac*}$	$7.5-\dfrac{\alpha^2}{2}-T^{ac*}$

Using Table 3 the expected social welfare function for the equilibrium ac-strategy, which is the sum of the product of the probability of the occurrence of an event and the realized social welfare is,

$$SW_a^{ac}(\alpha) = \begin{cases} 5+3.5\alpha-3\alpha^2, & \text{for } \alpha < \alpha_{max}, \\ 6-\dfrac{\alpha_{max}^2}{2}, & \text{for } \alpha \geq \alpha_{max}. \end{cases} \qquad (13)$$

$SW_a^{ac}(\alpha)$ is increasing in the monitoring rate till $\alpha < \alpha_{max} = \dfrac{1}{3}$. Since the monopoly results are restored for $\alpha \geq \alpha_{max}$ the social welfare function in this range of the monitoring rate is the sum of the monopoly profit and the corresponding consumer surplus net of the monitoring cost. Since $SW_a^{ac}(\alpha)$ is increasing in the monitoring rate, $\alpha_a^{ac*} = \alpha_{max}$ is the monitoring rate that maximizes $SW_a^{ac}(\alpha)$.

Let us now consider the aggressive strategy. The equilibrium limit output is the same as that in the case without anti-copying investment analyzed in Section 2. The equilibrium anti-copying investment is zero, that is $T^{ag*} = 0$. Intuitively, since the monopolist deters the pirate's entry using the limit output strategy it is not profitable to make any further investment in anti-copying technology. Hence the monopolist's profit (π_{ma}^{ag*}), consumer surplus (CS_a^{ag}) and the social welfare function (SW_a^{ag}) for the equilibrium ag-strategy is identical to those represented in equations (5), (6), and (7). Since $SW_a^{ag}(\alpha)$ is decreasing in the monitoring rate hence, $\alpha_a^{ag*} = 0$ maximizes $SW_a^{ag}(\alpha)$.

Figure 2 represents the comparison of the comparative static analysis of π_{ma}^{ac*} and π_{ma}^{ag*} with respect to α. This will be used to determine the social welfare maximizing monitoring rate.
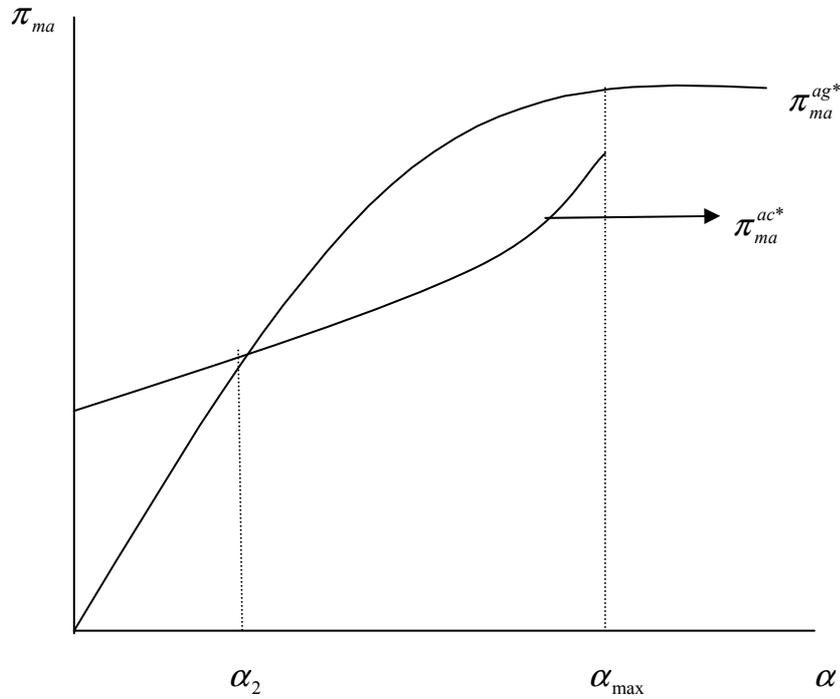
Figure 2: Comparison of comparative static analysis of monopolist's profit with anti-copying

Figure 2 shows that for $\alpha < \alpha_2$ the ac-strategy dominates the ag-strategy because in this range of the monitoring rate $\pi_{ma}^{ac*} > \pi_{ma}^{ag*}$. For $\alpha \geq \alpha_2$ the ag-strategy weakly dominates the ac-strategy because $\pi_{ma}^{ac*} \leq \pi_{ma}^{ag*}$. Let α_a^* be the socially optimal monitoring rate. Since $\alpha_a^{ac*} = \alpha_{max}$ maximizes $SW_a^{ac}(\alpha)$ and $\alpha_a^{ag*} = 0$ maximizes $SW_a^{ag}(\alpha)$, $\alpha_a^* \in \{0, \alpha_{max}\}$.

Proposition 2: $\alpha_a^* = \alpha_a^{ac*} = \alpha_{max}$ *is the socially optimal monitoring rate and the piracy is deterred in equilibrium.*

We provide an intuitive explanation of the proof. If government chooses $\alpha_a^{ac*} = \alpha_{max}$ then the monopolist can choose either aggressive or the accommodating strategies because the payoffs for each of them are the same and piracy is deterred. In this case there is no anti-copying investment in equilibrium and the social welfare is

$SW_a(\alpha_a^* = \alpha_{max}) = 6 - \dfrac{\alpha_{max}^2}{2}$ If the government chooses $\alpha_a^{ag*} = 0$ then the monopolist will choose the ac-strategy because it is dominant. In this case the optimal anti-copying investment is $T^{ac*} = 1$ and copying is prevented with certainty. The monopolist's profit is $\pi_{ma}^{ac*}(\alpha) = 3$. In this case the social welfare is

$SW_a(\alpha_a^* = 0) = 5$. Clearly, $SW_a(\alpha_a^* = \alpha_{max}) > SW_a(\alpha_a^* = 0)$ because

$6 - \dfrac{\alpha_{max}^2}{2} < 5$ since $\alpha_{max} = \dfrac{1}{3}$.

The upward sloping social welfare function for the equilibrium accommodating strategy is the main reason for this result. The intuition behind this property can be explained by the following four points.

(i) The anti-copying investment and the monitoring cost are the two deadweight losses in the social welfare function. The equilibrium anti-copying investment is inversely related to the monitoring rate. Both these costs lie in the interval 0 to 1. However, the monitoring cost $\frac{\alpha^2}{2}$ is less than the anti-copying investment cost which is T. This means an increase in the monitoring rate reduces the level of anti-copying investment but the increase in the cost of monitoring is less than the fall in the cost of anti-copying investment. Consequently, the social welfare function becomes increasing in the monitoring rate.

(ii) An increase in the monitoring reduces the possibility of the pirate's entry thereby reducing the consumer surplus. However, since the anti-copying investment increases due to an increase in the monitoring rate it increases the possibility of copying thereby raising the consumer surplus. The second effect dominates the first hence, consumer surplus is increasing in the monitoring rate.

(iii) An increase in the monitoring rate has a positive effect on the monopolist's equilibrium profit because the equilibrium anti-copying investment decreases.

(iv) Starting from no monitoring in which case the optimal anti-copying investment prevents copying, an increase in the monitoring rate initially increases the pirate's profit because it increases the possibility of copying. But beyond a critical level ($\alpha = \frac{1}{6}$, which we get by differentiating $\pi_{pa}^{ac*}(\alpha) = \alpha(1 - 3\alpha)$ with respect to α) the pirate's profit is decreasing in the monitoring rate because the chances of getting

detected increases which outweighs the gain from the increased possibility of copying.