COSTLY REPORTING, EX-POST MONITORING, AND COMMERCIAL PIRACY: A GAME THEORETIC ANALYSIS

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DISCUSSION PAPER 12.21
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Abstract:

This paper examines the regulatory authority’s decision, following a report from the legal firm, on monitoring commercial piracy in a market characterised by asymmetric product differentiation. I show that with ex-post monitoring the government will monitor piracy under both price and quantity competition if the legal firm’s political influence is sufficiently high. The study also finds that there exists a unique level of the relative cross-price impact of the pirate’s price on the legal firm’s output, above which monitoring will be higher under quantity competition, and below which monitoring will be higher under price competition. Moreover, I show that when the government can credibly commit to monitor piracy the legal firm’s investment on innovation is higher under quantity competition than under price competition.

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This paper borrows from one of the chapters of the author’s PhD thesis with Monash University.
1.1 Introduction

In this study, I investigate the decision of the regulatory authority to invest in monitoring commercial piracy when the legal firm has reported the presence of the pirate in the market. The existing literature on monitoring commercial piracy looks at ex-ante monitoring strategies where the authority, with the objective of maximising ex-ante social welfare, sets and commits to a level of monitoring before the pirate enters the market. However, empirical evidences show that often the authorities take monitoring decisions ex-post after the legal firm has taken the initiative to report piracy. This study attempts to bridge this gap in the literature by analysing ex-post monitoring decisions when the authority maximises a politically motivated objective function.

The issue of digital piracy for commercial profit has received a lot of attention in the industrial organisation literature over the last few years. Illegal competition from pirates reduces the revenue of the legal firm and this has been a concern of the digital media and software industry globally. This study is motivated by the observation of three important gaps in the literature on commercial piracy.

First, empirical evidences show that firms often need to incur costs to document and report signs of piracy, and then the regulatory authority decides whether or not and how much to invest in monitoring which, in turn, affects the probability that the pirate is being caught and convicted. For example\(^1\), Microsoft cooperated with the US Customs Services and the authority of twenty two countries to fight illegal sale of its products. In Argentina, in November 2000, following a report from the anti-piracy body of Microsoft, the Argentinean authority raided and apprehended six illegal sellers who were reported as selling counterfeit Microsoft softwares. In Brazil, Microsoft teamed up with the Specialized Police Department in Computer Crimes and initiated a police raid against Mega CD, a company that was selling unauthorised copies of Microsoft products over the web. The implications of costly reporting by the legal firm and ex-post monitoring by the authority have not been investigated.

\(^1\) Microsoft Corp (2004)
Second, pirated products are usually imperfect substitutes of the legal product. This implies that the impact of a change in the legal product’s price on the demand for the pirated product will be different from the impact of a change in the price of the pirated product on the legal firm’s demand. The existing literature on product differentiation, however, does not consider such kind of asymmetric product differentiation.

Third, this paper compares the monitoring level between the two cases of price and quantity competitions. It is expected that the incentives to monitor will be different between the two modes of competition but such comparisons have not been examined in the literature.

In my model, following the legal firm’s report of the presence of a pirate in the market the government decides whether or not and how much to invest in monitoring piracy in order to maximise a politically motivated objective function. I find that the threat of ex-post monitoring can credibly deter piracy. The authority will monitor piracy under both price and quantity competitions if the political influence of the legal firm is sufficiently high. I also show that there exists a unique level of product substitutability between the legal firm and the pirate above which monitoring will be higher under quantity competition and below which monitoring will be higher under price competition. That is, if the pirated product is a very close substitute to the product of the legal firm, then the government will be monitoring more intensively under quantity competition than under price competition. Moreover, when the government can credibly commit to monitor piracy, the legal firm’s investment on innovation is higher under quantity competition than under price competition.

1.2 An Overview of the Literature

Commercial piracy is rampant in the digital industry and is usually observed in sectors such as media and software, where it is easy to replicate a product at a very low or negligible cost to the pirate\(^2\). According to an estimate by the International Data Corporation

\(^2\) I am not considering end user piracy where copying is done for personal consumption and not for sale such as illegal downloading or P2P transfers (in case of software, media files etc) from the
(IDC) and the Business Software Alliance (BSA), global losses to piracy amounted to about $48 billion of which the US - the country most affected by this kind of illegal practice – accounted for over $8 billion during 2007\(^3\). Weekes (2008) claims that Australia loses over 200 million dollars annually due to piracy in the film and TV show industry despite the large copyright infringement penalty of AUD$65000 or five years imprisonment\(^4\). Thus illegal competition from pirates reduces the revenue of the legal firm and may provide a strong incentive\(^5\) for the legal firms to prevent piracy.

The literature on preventing piracy looks at both technical strategies and monitoring by the authority. Technical strategies imply that the legal firm invests in producing some anti-copying software, such as encryption devices, that would prevent illegal copying of its products. Banerjee (2003) shows that if the legal firm can cost-effectively install an anti-copying device in its product then no monitoring will be the social welfare-maximising equilibrium. However, just as it is easy to copy digital products, it is also easy to decode digital encryption and so technical protection may not be cost-effective. Therefore, the legal producers also put in effort to investigate and report piracy to the regulatory authority. Given the fact that it is costly for the firm to prepare and lodge a report, they will do so only if the expected benefit from apprehending the pirate is greater than the associated cost of investigating and reporting.

internet. There is a relatively large economic literature on end user copying. For a survey, see Peitz and Waelbroeck (2006).

\(^3\) See IDC and BSA (2007).


\(^5\) A firm may not report piracy if it offers some positive network benefits to the legal firm. Nascimento and Vanhonnacker (1988), Conner and Rumelt (1991), and Takeyama (1994) show that in the presence of network externalities, pirates could be helpful to the legal firms as they increase awareness of the legal products. Consumers can sample the less costly pirated products and then decide to buy a legal copy. Conner and Rumelt (1991) show that piracy is a less costly way of advertising the legal product to specific consumers only. Pirates can also increase the market for complementary products which can, as a feedback effect, advance the market for the legal product as well. Another way piracy can be beneficial is through “tacit reciprocity” when the pirate improves on the legal product and the legal producer, in turn, builds on the pirated product (see Kolm 2006, and El Harbi and Grolleau, 2008). In the current study we are abstracting away from such positive and network impacts of piracy.
On the regulatory front, the authority\footnote{By authority I mean any kind of regulatory authority including the government, the police, and piracy specific or industry specific regulatory units. Piracy specific or industry specific regulatory units are those where a firm can report piracy and seek monitoring services to protect their intellectual property/copy or patent rights, for example the Software & Information Industry Association, the Recording Industry Association of America and the Motion Pictures Association of America. These organisations work on behalf of their member firms to counter copyright infringements once such illegal activities are reported to them. These organisations work together with law enforcement bodies like the authority, the police and the court. For example, the Indian Music Industry (IMI, see http://www.indianmi.org/operations.htm) identifies production and sale of illegal copies of the digital products of its member firms, provides reports of their investigation to the regulatory authority and helps the police in conducting raids on the counterfeiters. In the raids conducted by the police following reports from the IMI, copying devices (computers, CD/DVD writers, blank CDs/DVDs) as well as counterfeit products (post-production) are confiscated and the counterfeiters arrested. In this paper, I am including all such organisations under the term ‘authority’.} is responsible for providing legal protection through monitoring and penalising illegal production. Following a tip-off from an outside source, who could be an investigator with the legal producer or an employee in the illegal firm or a concerned individual, the authority conducts raids on the suspect pirate firms. Given the huge amount of revenue loss due to piracy, the legal producers often find it worthwhile to investigate copyright infringements in their own domain and then report suspect activities to the authority.

There are numerous empirical examples of legal firms reporting piracy to the regulatory authority. Microsoft teamed up with the US Customs Services and the authority of twenty two countries to fight illegal sale of its products. In Argentina, in November 2000, following a report from the anti-piracy body of Microsoft, the Argentinean authority raided and apprehended six illegal sellers who were suspected of selling counterfeit Microsoft software. In Brazil, Microsoft informed the Specialized Police Department in Computer Crimes and initiated a police raid against Mega CD, a company that was selling unauthorised copies of Microsoft products over the web. The police apprehended two counterfeiters and confiscated over two thousand CDs with Microsoft software and several unused CDs (pre-production)\footnote{http://www.cdmediaworld.com/hardware/cdrom/news/0104/ms_piracy.shtml. The fact that pirates are caught before they are able to sell in the market will be used in this study where the legal firm detects the presence of the pirate before the pirate actually starts operating in the output market.}.

However, the existing literature on monitoring copyright infringement regarding both end-user and commercial, looks at the case where, before the pirate enters the market, the
authority makes its ex-ante social welfare-maximising monitoring decision. Thus, this literature assumes that the authority can commit to the ex-ante choice of the monitoring effort. In this case, the literature finds that the equilibrium would be no monitoring since increased competition from the pirate increases the balance of the consumer surplus vis-à-vis profit of the legal firm as components of social welfare. Thus, an increase in monitoring decreases social welfare due to higher price and under-production of the legal product.

That monitoring reduces social welfare has been shown by Novos and Waldman (1984), Noyelle (1990), Cheng et. al. (1997), Chen and Png (1999) and Harbough and Khemka (2000), in the context of end-user piracy and by Banerjee (2003, 2006), Banerjee and Mukherjea (2007) and Kiema (2008), in the context of commercial piracy. A general conclusion of the above studies is that a pricing strategy by the legal firm is more effective in preventing piracy than an ex-ante monitoring strategy by the authority whose objective is to maximise social welfare. This is because the high price of legal software products is the dominant reason for piracy and since piracy makes more products available to the consumers at a low price, the loss to the legal firm is outweighed by the gain to the consumer surplus in the social welfare function. Hence, monitoring is not a welfare maximising strategy.

The literature suggests that monitoring is not optimal when the authority is maximising social welfare if this is a simple sum of the profits of the legal firm and the pirate and the consumer surplus. Empirically, however, we do observe that monitoring by the authority takes place. Thus, a natural conjecture is that the objective function of the authority is not a simple social welfare function but is weighted by the political influence of the legal firm, the pirate and the consumers. Thus, the authority will monitor if it has a politically

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8 Monitoring is even more undesirable when there are some positive network externalities or feedback effects to the legal firm due to the presence of piracy. This issue has been addressed by Church and Gandal (1992), Shurmer (1993), Gandal (1994, 1995), Shy and Thisse (1999), Park and Scotchmer (2005) and Poddar (2005). Piracy can also be treated as a special case of discriminatory pricing where the legal seller considers piracy equivalent to charging zero price to consumers with lower willingness to pay or lower quality preference and charging higher price to consumers with a higher willingness to buy the better quality but more expensive legal product. In this context, for end user piracy, Takeyama (1994) and Slive and Bernhardt (1998) show that allowing piracy is socially optimal. Bae and Choi (2006) show that more originals are sold, and at a lower price, if illegal copies exist in the market and hence optimal equilibrium requires that piracy should be allowed.
motivated objective function with a sufficiently high weight for the legal firm’s profit relative to the surplus to the consumers.

The issue of a political lobby influencing ex-ante monitoring decisions has been addressed by Banerjee (2006) in the context of commercial piracy. He shows that if the authority maximises a simple social welfare function where the profits of the legal firm and the pirate and the consumer surplus are equally weighted, then there will be no monitoring in equilibrium. This is because when the authority maximises such a simple social welfare function, the benefits to the consumers and the pirate together always exceed the loss to the legal firm. Thus piracy increases the social benefit and it is optimal for the authority to allow the pirate to operate in the market. However, if the legal firm has a higher weight than the pirate or the consumers in the objective function of the authority, then the authority will monitor piracy. In the case of a politically motivated objective function, the trade-off between the surpluses of the consumers and of the legal producers and hence, the monitoring decision of the authority can go either way depending on the relative political influence of the legal firm and the consumers.

Following Banerjee (2006) I also consider a politically motivated objective function of the authority. However, I impose some stricter assumptions. First, I assume that the authority is only looking at the benefit to the legal producer and the consumers. That is, the political influence of the pirate is negligible and the pirate’s benefits are not considered by the authority when it makes its monitoring decisions. Thus, the political objective function of the authority is the weighted sum of the legal firm’s profit and the consumer surplus. The benefit to the pirate is not considered explicitly by the authority but implicitly through a higher consumer surplus. Second, Banerjee (2006) has that lobbying by the legal producer increases the weight on his profit without affecting the weight on the surpluses of the other agents in the authority’s objective function. I, on the other hand, allow for the fact that as the lobbying pressure of the legal producer grows the authority may ‘penalise’ the consumers by reducing the weight on consumer surplus in its objective function. This emphasises the trade-
off between the surpluses of only the legal firm and the consumers when the authority monitors piracy vis-à-vis when it does not.

Also, Banerjee (2006) considers ex-ante monitoring where the authority sets its anti-piracy strategy before the legal producer or the pirate enter and strategically interact in the market. However, the regulatory authority need not commit to the ex-ante monitoring decision once the pirate enters the market. In this paper, I investigate the case where the threat of monitoring is more credible since the authority takes its monitoring decisions after the legal firm reports the pirate. This is in line with the anecdotal evidences, as presented earlier, where the regulatory authorities act after the piracy has been reported.

Besides examining ex-post monitoring, we also analyse whether the mode of competition between the legal firm and the pirate influences the monitoring decision of the authority. The literature on monitoring commercial piracy only considers price competition. However, there is a substantial literature\(^9\) that shows that quantity competition is more profitable than price competition if the products are substitutes. In my model, the pirated copy is an imperfect substitute of the original product, and I will analyse how quantity competition vis-à-vis price competition in the product market affects the magnitude of the authority’s monitoring decision.

In this study, I assume that the authority gets to know about the presence of a pirate only if the legal firm detects and reports the presence of a pirate in the market. I assume that the probability of detecting the copyright infringer is proportional to the monitoring rate. If there is no regulatory intervention, the pirate and the legal firm compete sequentially in price or quantities with the legal firm as the leader. Then this paper goes on to analyse a model where the regulatory authority maximises a politically motivated objective function, given as a weighted sum of the legal firm’s profit and the consumer surplus.

\(^9\) For example, see Gal-Or (1985) and Boyer and Moreaux (1987a,b) in the context of sequential games; Vives (1985), and Cheng (1985) analyse price and quantity strategies for simultaneous games.
First, I show that for both price and quantity competition, the equilibrium monitoring rate chosen by the authority will depend on i) the degree of product substitutability, ii) the relative weight it puts on the legal firm’s profit vis-à-vis the consumer surplus, iii) the marginal cost of monitoring, and iv) the extent to which piracy changes the legal firm’s profit and the consumer surplus. Second, this paper also finds that there exists a critical degree of product substitutability below which the authority will monitor at a higher intensity under price competition than under quantity competition and vice versa.

The paper is laid out as follows. In section 2, I develop the model for ex-post monitoring when the firms compete in price, and I analyse how the optimal monitoring rate varies with the political influence of the legal firm in the authority’s objective function. In sections 3 and 4, I examine the case for quantity competition and provide a comparison between the equilibria under the two modes of competition. In section 5, I analyse how the decision to invest in R&D by the legal firm is affected by the mode of competition in the product market and the monitoring decision by the authority. In the last section I summarise the main finding of this paper and conclude.

2. Model: Ex-Post Monitoring under Price Competition

In the absence of piracy, let the market for the legal product be given by \( q = 4 - 2p \), where \( p \) is the price and \( q \) is the quantity demanded. The profit maximising equilibrium for this monopoly case can be described as \( p_m^* = 1, \ q_m^* = 2, \ \pi_m^* = 2 \) and \( CS_m^* = 1 \), where \( \pi_m \) is the monopoly profit of the legal firm and \( CS_m \) is the consumer surplus. In this model, piracy creates a market for differentiated goods where the legal product and the copy are imperfect substitutes. Typically, this can happen because of the quality difference between the legal product and the pirated copy. The demands for the products are determined by their own-price and the cross-price impacts. Without loss of generality, let the legal firm be firm 1 and the pirate be firm 2. Let \((q_i, p_i)\) for \( i = 1, 2 \), denote firm \( i \)’s quantity and price. Building on Singh and
Vives (1984) and Boyer and Moreaux (1987b), I consider a differentiated product market characterized by the following demand functions.

\[
\begin{align*}
q_1 &= 1 - p_1 + c_1 p_2 \\
q_2 &= 1 - p_2 + c_2 p_1
\end{align*}
\]  

(1)

where the cross-price impacts, given by \(c_1\) and \(c_2\) are asymmetric, that is, their absolute values may differ. The own-price effects for both demand functions are normalised to 1.

Note that i) if the products were perfect substitutes or the own-price effects and cross-price effects for both firms were equal, that is \(c_1 = c_2 = 1\), and ii) if the two firms charge the same monopoly price, say, \(p_1 = p_2 = p_m = 1\), then \(q_1 = q_2 = 1 = \frac{q_m}{2}\) and \(\pi_1 = \pi_2 = 1 = \frac{\pi_m}{2}\).

Therefore, the total market \(q = 4 - 2p\) is shared equally by the two firms if their products were perfect substitutes. This confirms that the demand structure is consistent under any form of competition structure. For tractability of analysis, the demand functions are normalised to

\[
\begin{align*}
q_1 &= 1 - p_1 + c p_2 \\
q_2 &= 1 - p_2 + p_1
\end{align*}
\]  

(2)

That is, the impact of the price of the legal firm on the demand for the pirated product is higher than the impact of the price of the pirated product on the demand for the legal product or \(0 < c_1 = c < 1 = c_2\). The assumption that \(c > 0\) implies that the products are substitutes and \(c < 1\) implies that the own price impact exceeds the cross-price impact for the demand of the legal product. \(^{10}\) I further assume that production is costless and the degree of substitutability \(c\) to be exogenously given.

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\(^{10}\)This analysis retains the symmetric costs (zero marginal cost) assumption as in Singh and Vives (1984) and Boyer and Moreaux (1987b). However, I depart from their assumption of same cross-price impact and assume that cross-price impacts are asymmetric between the two demand structures. This demand system also excludes the case of perfect substitutes, that is, when the own-price effects and cross-price effects are same across the two demand functions.
The regulatory body chooses a level of monitoring, $\alpha$, that maximizes its political objective function subject to the cost of monitoring, $C(\alpha)$ . So that the maximum can exist, it must be that $C(0) = 0$, $C'(\alpha) > 0$ and $C''(\alpha) > 0$ . Let the monitoring cost be given as

$$C(\alpha) = \frac{k\alpha^2}{2}$$

where $k$ is the institutional parameter representing the efficiency of the authority, with a higher $k$ implying less efficient or more costly regulatory system. I assume that the probability, $P$, that a pirate gets caught depends positively on the monitoring effort of the authority, that is $P = P(\alpha)$ with $P(0) = 0$, $P'(\alpha) > 0$, $P''(\alpha) < 0$ and $P(\infty) = 1$. For simplicity, let $P(\alpha) = \alpha$, i.e. the monitoring rate is also the rate of detecting and apprehending the pirate. Therefore, $P(\alpha \geq 1) = 1$, $1 > P(\alpha) = \alpha > 0$ and $k$ must be sufficiently large in the cost function to ensure that monitoring cost is not restricted to a fraction. The timing of the game is as follows:

**Stage 1:** The pirate decides whether to enter the market. If it does not enter, the game ends with the legal firm as a monopolist. If the pirate enters, it has to incur an entry cost of $F$.

**Stage 2:** If the pirate enters, the legal firm decides whether to report the pirate to the authority. If it does not report, the game ends. If it reports, it incurs a reporting cost of $R$.

**Stage 3:** If the pirate enters and the legal firm reports, then the authority chooses a monitoring rate $\alpha \in [0,1]$.
**Stage 4:** If piracy cannot be detected or if the legal firm does not report, then the legal firm and pirate compete sequentially in price with the legal firm as the leader.

If piracy is detected, the legal firm gets a monopoly in the product market.\(^{11}\)

I assume that the pirate’s entry cost, \(F\), and the legal firm’s reporting cost, \(R\), are both sunk costs. The authority monitors piracy after the legal firm reports the presence of piracy. The authority maximises a politically weighted objective function (henceforth, political objective function)\(^{12}\), \(W\), which is a weighted sum of profit and consumer surplus (CS) such that \(W = \beta \pi_1 + \gamma \pi_2 + (1 - \beta - \gamma)CS\). Here, \(\beta\) is the weight of the legal firm, \(\gamma\) is the weight of the pirate and \((1 - \beta - \gamma)\) is the weight of the consumers in the political objective function. For simplicity, I assume that the political power of the pirate in influencing the authority is negligible or zero, implying that the authority is not corrupt. That is,

\[
W = \beta \pi_1 + (1 - \beta)CS; \quad \gamma = 0.
\] \hspace{1cm} (4)

The authority decides upon the monitoring rate \(\alpha\) that maximises \(W\). If the pirate’s illegal activities are detected with probability \(P(\alpha) = \alpha\), then the pirate is apprehended before the production stage and incurs the (sunk) entry cost of \(F\). The game is solved by backward induction.

In Stage 4, if the pirate is not detected by the authority, the legal firm and the pirate play a sequential price Stackelberg game with the legal firm as the leader. The equilibrium price, quantity and profit of the legal firm (firm 1) and the pirate (firm 2), respectively, are:

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\(^{11}\) I abstract away from the case where the pirate has to pay a fine if caught. The literature on monitoring piracy assumes that the pirate will be penalised if caught. In this model, the penalty is fixed at zero for simplicity of analysis. A positive penalty will reinforce the findings of this paper.

\(^{12}\) Banerjee (2006) uses a social welfare function which captures lobbying by the legal firm. In his model, the consumer surplus and pirate’s profit are each weighted at one and the legal firm’s profit weighted at more than one. However, the present study generalises the objective function used by Banerjee (2006) and presents a sharper trade-off between the legal firm’s profit and consumer surplus with and without piracy. Thus this paper looks at a wider range of political influence of the legal firm vis-à-vis the consumers in the objective function of the authority.
\[ p_1^* = \frac{2 + c}{4 - 2c}, \quad q_1^* = \frac{2 + c}{4}, \quad \pi_1^* = \frac{(2 + c)^2}{8(2 - c)} - R, \]

\[ p_2^* = \frac{1}{2} + \frac{2 + c}{2(4 - 2c)}, \quad q_2^* = \frac{1}{2} + \frac{2 + c}{2(4 - 2c)} \quad \text{and} \quad \pi_2^* = \frac{(6 - c)^2}{(8 - 4c)^2} - F. \quad (5) \]

The superscript P indicates price competition in the product market. Thus the total consumer surplus for the price game is given as

\[ CS^*_{\text{P}} = \frac{52 - 12c - 7c^2 + c^4}{32(2 - c)^3}. \quad (6) \]

If the pirate is detected by the authority, then the legal firm gets to be a monopolist in the market and then the equilibrium monopoly outcome will be

\[ p_m^* = 1, \quad q_m^* = 2, \quad \pi_m^* = 2 - R \quad \text{and} \quad CS_m^* = 1. \quad (7) \]

![Figure 1: The Ex-Post Monitoring Game](image-url)
In Stage 3, following a report from the legal firm, the authority decides on the equilibrium level of monitoring, as illustrated in Figure 1. The regulator will choose a monitoring rate $\alpha$ that maximises the expected political objective function (EW) after the legal producer reports.

$$EW = \alpha \left[ \beta (\pi_m^*) + (1 - \beta) CS_m^* - \frac{k\alpha^2}{2} \right] + (1 - \alpha) \left[ \beta (\pi_1^{*p}) + (1 - \beta) CS^{*p} - \frac{k\alpha^2}{2} \right]$$
or,

$$EW = \alpha \left[ \beta (\pi_m^* - \pi_1^{*p}) + (1 - \beta)(CS_m^* - CS^{*p}) \right] + \beta (\pi_1^{*p}) + (1 - \beta) CS^{*p} - \frac{k\alpha^2}{2}. \quad (8)$$

The expected ‘benefit’ ($EB$) to the authority is

$$EB = \alpha \left[ \beta (\pi_m^*) + (1 - \beta) CS_m^* \right] + (1 - \alpha) \left[ \beta (\pi_1^{*p}) + (1 - \beta) CS^{*p} \right]$$

and the cost is given as $C = \frac{k\alpha^2}{2}$. The expected marginal benefit is thus given as

$$EMB = \left[ \beta (\pi_m^*) + (1 - \beta) CS_m^* \right] - \left[ \beta (\pi_1^{*p}) + (1 - \beta) CS^{*p} \right]$$

and the marginal cost of monitoring is given as $MC = k\alpha$. Now $MC = k\alpha > 0$ for $k, \alpha > 0$. The authority will never monitor if the marginal benefit from duopoly exceeds that from monopoly. Thus, monitoring will take place only if marginal benefit from duopoly exceeds that from monopoly or

$$\beta (\pi_m^* - \pi_1^{*p}) + (1 - \beta)(CS_m^* - CS^{*p}) = k\alpha > 0,$$

that is when $EMB = MC$ and the benefit to the legal firm from the monopoly outweighs the loss in consumer surplus due to reduced competition. Therefore, monitoring will take place only if

$$\beta > \frac{116c - 39c^2 + c^4 - 76}{148 - 156c + 33c^2 + 4c^3 + c^4} = \beta^p. \quad (9)$$

If $\beta < \beta^p$ then the expected marginal benefit from monitoring is negative and, given that monitoring is costly, the authority would choose no monitoring, that is $\alpha^* = 0$. If $\beta > \beta^p$, then the authority will maximise the EW by monitoring at the level where marginal benefit from monitoring (EMB) equals the marginal cost (MC) of monitoring. This optimal level of monitoring is given as
Proposition 1: (i) There exists a unique critical level of political power, \( \beta^p \), of the legal firm beyond which the authority monitors piracy in equilibrium under price competition in the product market. That is, if \( \beta < \beta^p \) then \( \alpha^* = 0 \); if \( \beta > \beta^p \), then \( \alpha^* > 0 \).(ii) \( \alpha^* \) increases with the level of political power, \( \beta \), and decreases with the cost of monitoring, \( k \).

The proposition is illustrated in Figure 2 which shows the expected marginal benefit and the marginal cost of monitoring. It can be seen that if \( \beta < \beta^p \) then the EMB is negative, implying that the benefit under duopoly is higher than that under monopoly. Because marginal cost is always positive, the equilibrium outcome should have no monitoring by the authority; however, if \( \beta > \beta^p \), then the benefit under monopoly exceeds that from the duopoly, and there exists a unique critical level of monitoring by the authority in equilibrium which is given by \( MC=EMB \).

\[
\alpha^* = \frac{\beta(148 - 156c + 33c^2 + 4c^3 + c^4) - 116c + 39c^2 - c^4 + 76}{32k(2-c)^2}.
\]

![Figure 2: Monitoring Equilibrium under the Price Game](image-url)
As the political power of the legal firm increases, the weight on the profit of the legal firm increases and thus the weight on the benefit to the consumers go down in the authority’s objective function. Hence with higher $\beta$ the monitoring effort increases. On the other hand, if the inefficiency of the authority increases, that is, with a higher $k$ as monitoring becomes more costly, then the equilibrium level of monitoring goes down. In Figure 2, the intersection of a higher $MC$ with the $EMB$ will be to the left of $\alpha^{*p}$.

\[\beta (\pi_m^* - \pi_1^{*p}),\]
\[(1-\beta)(CS^{*p} - CS_m^*)\]

\[\beta (\pi_m^* - \pi_1^{*p})\]
\[(1-\beta)(CS^{*p} - CS_m^*)\]

**Figure 3: Comparing Legal Monopoly with Piracy in the Price Game**

Let me now examine the relative influences of the legal firm and the consumers on the monitoring decision of the authority. Starting from the equilibrium condition of $MC=EMB$, we have

\[\frac{\beta}{1-\beta} = \frac{CS^{*p} - (CS_m^* - k\alpha)}{(\pi_m^* - k\alpha) - \pi_1^{*p}}.\]

Thus we will have $\beta \geq 1-\beta$ when $CS^{*p} - (CS_m^* - k\alpha) \geq (\pi_m^* - k\alpha) - \pi_1^{*p}$. This says that if consumer surplus with piracy is higher than the legal firm’s profit without piracy, then the legal firm has to have a stronger lobbying power vis-à-vis the consumers so that the authority monitors piracy. Figure 3 shows how the trade-off between the profit of the legal firm and the consumer surplus with and without piracy changes with the degree of product substitutability, $c$. For a sufficiently high $c$,
the difference in consumer surplus with piracy vis-à-vis a legal monopoly outweighs the profit difference from monopoly vis-à-vis the illegal competition situation. Hence, when the degree of product substitutability is high, a higher share of the consumers relative to the legal firm in the total surplus would prompt the authority not to monitor piracy. Thus, if \( c \) is sufficiently high, the legal firm must have a higher weight in the political objective function of the authority in order to induce monitoring in equilibrium.

In stage 2 of the game, the legal firm will decide to report or not. It will report if the expected profit following the report exceeds that from not reporting. Thus, the legal firm will report if

\[
\alpha^* p \left(2 - R\right) + \left(1 - \alpha^* p\right) \left(\frac{(2 + c)^2}{8(2 - c)} - R\right) > \frac{(2 + c)^2}{8(2 - c)}. \tag{11}
\]

or if \( R < \alpha^* p \left(2 - \frac{(2 + c)^2}{8(2 - c)}\right) = R^p \) where \( \alpha^* p > 0 \). If \( \alpha^* p = 0 \), then the legal firm will never report.

**Proposition 2:** (i) Under price competition, if the political influence of the legal firm is sufficiently high to induce monitoring, the legal firm will report piracy only if the cost of reporting is below a critical level. That is, if \( \beta > \beta^p \), so that \( \alpha^* p > 0 \), then the legal firm will report if \( R < R^p \) and will not report if \( R \geq R^p \). (ii) If \( \beta < \beta^p \) so that \( \alpha^* p = 0 \) then not reporting is the equilibrium.

In stage 1, the pirate will decide to enter or not. The pirate’s decision depends on the decision of the legal firm to report following the entry of the pirate. If \( \alpha^* p > 0 \) and the legal firm has \( R \geq R^p \) or if \( \alpha^* p = 0 \) then the legal firm will not report and then the pirate will enter if \( \pi^* p = \frac{(6 - c)^2}{(8 - 4c)^2} - F > 0 \) or if \( \frac{(6 - c)^2}{(8 - 4c)^2} > F \). If \( \alpha^* p > 0 \) and the legal firm has
then the pirate will enter if his expected duopoly profit following the report exceeds that from not entering. Thus, the pirate will enter if

\[ \alpha^p (-F) + (1 - \alpha^p) \left( \frac{(6-c)^2}{(8-4c)^2} - F \right) > 0 \text{ or if } (1 - \alpha^p) \left( \frac{(6-c)^2}{(8-4c)^2} \right) = F^* > F. \]  (12)

**Proposition 3:** If \( \beta > \beta^p \), \( R < R^p \) and \( F < F^p \) then the sub-game perfect equilibrium will have the pirate entering, the legal firm reporting and the authority monitoring piracy.

3. Model: Ex-Post Monitoring under Quantity Competition

In this section, I consider the same market structure as in section 2, except that in Stage 4, the legal firm and the pirate play a sequential *quantity* game, instead of a price game, with the legal firm as the leader. The equilibrium price, quantity and profit of the legal firm are given by

\[
\begin{align*}
p_1^Q &= \frac{1}{2(1-c)}, \quad q_1^Q = \frac{1}{2-c} \quad \text{and} \quad \pi_1^Q = \frac{1}{2(1-c)(2-c)} - R, \\
\end{align*}
\]  (13)

and those for the pirate are given by

\[
\begin{align*}
p_2^Q &= \frac{3-2c}{2(2-c)(1-c)}, \quad q_2^Q = \frac{3-2c}{2(2-c)} \quad \text{and} \quad \pi_2^Q = \frac{(3-2c)^2}{4(2-c)^2(1-c)} - F. \\
\end{align*}
\]  (14)

Thus the total consumer surplus for the quantity game is given by

\[
CS^Q = \frac{13 - 12c + 4c^2}{8(2-c)^2}. \]  (15)

The superscript \( Q \) denotes quantity competition in the product market. As in section 2, if the pirate is detected by the authority, then the legal firm gets to be a monopolist in the market and then the equilibrium monopoly outcome will be

\[
p_m^* = 1, \quad q_m^* = 2, \quad \pi_m^* = 2 - R \text{ and } CS_m^* = 1. \]  (16)
In Stage 3, following a report from the legal firm, the authority decides on a monitoring rate $\alpha$ that maximises the expected political objective function (EW) after the legal producer reports.

$$EW = \alpha \left[ \beta (\pi_m^* - \pi_i^*) + (1 - \beta)(CS_m^* - CS_i^*) \right] + \beta (\pi_i^*) + (1 - \beta)CS_i^* - \frac{k\alpha^2}{2}. \quad (17)$$

The expected marginal benefit or $EMB = [\beta (\pi_m^*) + (1 - \beta)CS_m^*] - [\beta (\pi_i^*) + (1 - \beta)CS_i^*]$ and the marginal cost of monitoring is given as $MC = k\alpha > 0$ for $k, \alpha > 0$. Thus, monitoring by the authority will take place if $EMB = MC$ or $\beta (\pi_m^* - \pi_i^*) + (1 - \beta)(CS_m^* - CS_i^*) = k\alpha > 0$, when benefit to the legal firm from the monopoly due to reduced competition outweighs the loss in consumer surplus. Hence, monitoring will take place only if

$$\beta(2-R) + (1-\beta) > \beta \left( \frac{1}{2(1-c)(2-c)} - R \right) + (1-\beta) \frac{13-12c + 4c^2}{8(2-c)^2}$$

or $\beta > \frac{39c - 24c^2 + 4c^3 - 19}{37 - 85c + 56c^2 - 12c^3} = \beta^Q. \quad (18)$

If $\beta > \beta^Q$, then the authority will maximise EW by monitoring at the level

$$\alpha^* = \frac{\beta(37 - 85c + 56c^2 - 12c^3) - 39c + 24c^2 - 4c^3 + 19}{8k(2-c)^2(1-c)}. \quad (19)$$

---

**Figure 4: Monitoring Equilibrium under the Quantity Game**
**Proposition 4:** (i) There exists a unique critical level of political power, $\beta^0$, of the legal firm beyond which the authority monitors piracy in equilibrium under quantity competition in the product market. That is, if $\beta < \beta^0$ then $\alpha^* = 0$; if $\beta > \beta^0$, then $\alpha^* > 0$. (ii) $\alpha^*$ increases with the level of political power, $\beta$, and decreases with the cost of monitoring, $k$.

Proposition 4 is illustrated in Figure 4 which shows the expected marginal benefit and the marginal cost of monitoring. It can be seen that if $\beta < \beta^0$ then the EMB is negative, implying that the benefit under duopoly is higher than that under monopoly. Marginal cost being always positive, the equilibrium outcome should have no monitoring by the authority. However, if $\beta > \beta^0$, then the benefit under monopoly exceeds that from the duopoly, and there exists a unique critical level of monitoring by the authority in equilibrium such that $MC=EMB$. As the political power of the legal firm increases, the weight on the profit of the legal firm increases and thus the weight on the benefit to the consumers go down in the authority’s objective function. Hence with higher $\beta$ the monitoring effort increases. If the inefficiency of the authority increases, that is, with a higher $k$ monitoring becomes more costly, then the equilibrium level of monitoring will go down. In Figure 4, the intersection of a higher MC with the EMB will be to the left of $\alpha^*$.

Figure 5 shows how the trade-off between the profit of the legal firm and the consumer surplus changes with the degree of product substitutability, $c$. For a sufficiently high $c$, the difference in consumer surplus with piracy vis-à-vis a legal monopoly outweighs the profit difference from monopoly vis-à-vis the illegal competition situation. Hence, when the degree of product substitutability is high, a higher share of the consumers relative to the legal firm in the total surplus would prompt the authority not to monitor piracy. Thus, if $c$ is sufficiently high, the legal firm must have a higher weight in the political objective function of the authority in order to induce monitoring in equilibrium.
\[
\beta(\pi^*_m - \pi^*_1) - (1 - \beta)(CS^{\alpha}_c - CS^*_m)
\]

Figure 5: Comparing Legal Monopoly with Piracy in the Quantity Game

In stage 2 of the game, the legal firm will decide to report or not. It will report if the expected profit following the report exceeds that from not reporting. Thus, the legal firm will report if

\[
(1 - \beta)(CS^{\alpha}_c - CS^*_m) > \beta(\pi^*_m - \pi^*_1)
\]

or if \( R < \alpha^* \left( 2 - \frac{1}{2(1-c)(2-c)} \right) = R^* \) where \( \alpha^* > 0 \). If \( \alpha^* = 0 \), then the legal firm will never report.

**Proposition 5:** (i) Under quantity competition, if the political influence of the legal firm is sufficiently high to induce monitoring, the legal firm will report piracy only if the cost of reporting is below a critical level. That is, if \( \beta > \beta^0 \), so that \( \alpha^{\alpha Q} > 0 \), then the legal firm will report if \( R < R^{\alpha Q} \) and will not report if \( R \geq R^{\alpha Q} \). (ii) If \( \beta < \beta^0 \) so that \( \alpha^{\alpha Q} = 0 \) then not reporting is the equilibrium.
In stage 1, the pirate will decide to enter or not. The pirate’s decision depends on the
decision of the legal firm to report following the entry of the pirate and the cost of entry. If
\( \alpha^* > 0 \) and the legal firm has \( R \geq R^* \) or if \( \alpha^* = 0 \) then the legal firm will not report and
then the pirate will enter if \( \pi_2^* = \frac{(3-2c)^2}{4(2-c)^2(1-c)} - F > 0 \) or if \( \pi_3^* = \frac{(3-2c)^2}{4(2-c)^2(1-c)} > F \). If
\( \alpha^* > 0 \) and the legal firm has \( R < R^* \) then the pirate will enter if his expected duopoly
profit following the report exceeds that from not entering. Thus, the pirate will enter if
\[ \alpha^*(F) + (1-\alpha^*)(\frac{(3-2c)^2}{4(2-c)^2(1-c)} - F) > 0 \]
or if \( (1-\alpha^*)(\frac{(3-2c)^2}{4(2-c)^2(1-c)}) = F^* > F \). \( \text{(21)} \)

**Proposition 6:** If \( \beta > \beta^0 \), \( R < R^* \) and \( F < F^* \) then the sub-game perfect equilibrium will
have the pirate entering, the legal firm reporting and the authority monitoring piracy.

4. Comparing the Equilibria under Price and Quantity Competition

This section compares the equilibrium monitoring efforts for the case where the pirate
enters and the legal firm reports in equilibrium under both price and quantity competitions.
Thus, \( R < R^* \), \( R^p \) and \( F < F^* \), \( F^p \). Whether the monitoring effort under price competition
will be higher or lower than the monitoring effort when the firms compete in quantities will
depend upon the relative political pressure exerted by the legal firm on the authority.

I find that \( \beta^p > \beta^o \) if \( c > \bar{c} \). That is, there exists a unique critical degree of substitutability
beyond which price competition, compared to quantity competition, requires a higher level of
political power of the legal firm to ensure credible monitoring effort by the authority. The
closer a substitute the pirated copy is to the legal product, the less is required of the legal firm
to lobby the authority under quantity competition. This is because when there is a high degree of product substitutability, if the pirate enters the benefit to the consumers is lower under quantity competition and higher under price competition. In this case, for $c > \bar{c}$, if $\beta^p < \beta < \beta^Q$, then the equilibrium monitoring condition will have positive monitoring under quantity competition and no monitoring under price competition. This is shown by the area D in Figure 3.6. If $\beta > \beta^p$, then, as shown by area B, there will be monitoring in equilibrium for both price and quantity competition, however, monitoring will be higher under quantity competition than under price competition.

![Figure 3.6: Comparing Monitoring between the Price and Quantity Games](image)

If $c < \bar{c}$ then we find that $\beta^Q > \beta^p$. That is, if the pirated product is not a close substitute of the legal product, then there exists a critical degree of substitutability beyond which the political influence of the legal firm has to be higher under quantity competition than price competition to ensure credible monitoring effort by the authority. If the pirated copy is a significantly inferior substitute to the legal product, the less is required of the legal firm to lobby the authority because if the pirate enters it increases the total size of the market.
under price competition. The benefit to the legal firm is higher under price competition and lower under quantity competition when the pirate operates in the market. In this case, for \( c < \tilde{c} \), if \( \beta^0 < \beta < \beta^p \), then the equilibrium monitoring condition will have positive monitoring under price competition and no monitoring under quantity competition. This is shown by the area C in Figure 3.6. If \( \beta > \beta^0 \), then, as shown by area A, there will be monitoring in equilibrium for both price and quantity competition, however, monitoring will be higher under price competition than under quantity competition. The area E illustrates the case when \( \beta < \beta^0 \) and \( \beta < \beta^p \) such that there is no monitoring under both price and quantity competitions.

**Proposition 7:** For a sufficiently high level of political influence of the legal firm such that the authority will choose to monitor piracy under both price and quantity competition, there exists a unique level of product substitutability between the legal firm and the pirate above which monitoring will be higher under quantity competition and below which monitoring will be higher under price competition. That is, if \( Q > \beta^0 \) and \( P > \beta^p \), there exists a unique level of product substitutability \( \tilde{c} \) such that if \( c > \tilde{c} \) then \( \alpha^* > \alpha^* > 0 \) and if \( c < \tilde{c} \) then \( \alpha^* > \alpha^* > 0 \).

Thus, there exists a critical degree of substitutability, \( \tilde{c} \), between the demands for the legal product and the pirated product such that if \( c > \tilde{c} \) then higher political pressure is required by the legal firm under price competition compared to quantity competition, to ensure credible monitoring. If \( c < \tilde{c} \) then higher political pressure is required by the legal firm under quantity competition compared to price competition, to ensure credible monitoring. That is, the more imperfect a substitute the pirated product is to the legal product, the government’s optimal monitoring rate will be higher under price competition than under quantity competition. If the pirated product is a very close substitute to the product of the
legal firm, then the government will be monitoring more intensively under quantity competition than under price competition. If the level of political power of the legal firm is high enough to ensure credible monitoring under both price competition and quantity competition, that is if $\beta > \beta^Q$ and $\beta > \beta^P$, then monitoring is always optimal in equilibrium; alternatively, if $\beta < \beta^Q$ and $\beta < \beta^P$ then not monitoring will be the optimal in equilibrium.

5. Introducing Innovation by the Legal Firm

Piracy has generally been perceived as having a harmful impact on the digital industry where the products can be copied at a low cost (Marshall, 1999; Straub and Nance, 1990). This issue assumes importance not only because of the high magnitude of the loss in retail sales but also because piracy reduces the incentive to innovate by the legal firms. Novos and Waldman (1984) find that piracy induces higher copyright protection and underproduction in the legal sector thereby reducing social welfare. Park and Ginarte (1996) also support this observation. Qiu (2006) shows that, if copyright protection is weak, then the legal product is only developed for a small number of customers willing to pay a high price and not for general use. In an empirical study, Ding and Liu (2009) find that under weak Intellectual Property Right (IPR) regimes piracy dissuades the legal firms to invest on the development of new technologies. Jaisingh (2009) shows that innovative investment increases with stronger enforcement of regulatory measures to apprehend copyright infringers.

In this section, I investigate how the mode of competition and the degree of product substitution between the legal firm and the pirate determine the investment in innovation by the legal firm. I consider that the legal firm operates in the product market if the innovation is successful, with the probability of success given by $\mu(X)$ where $X$ is the expenditure on

---

13 Piracy may also have beneficial impacts on innovation. Beneficial effects of piracy could be through positive feedback effects on the legal firm’s innovative efforts (Easley et al., 2003; Kolm, 2006; El Harbi and Grolleau, 2008) or through raising awareness of the legal product by providing a cheaper, albeit poorer, substitute (Conner and Rumelt, 1991). I do not consider such beneficial network effects in the current study.
Research and Development (R&D) for innovation. I assume that $\mu(0) = 0, \mu(\infty) = 1, \mu'(X) > 0$ and $\mu''(X) < 0$. If the new product is successfully developed, then the legal firm faces the threat of a pirate entering with an imperfect copy and competing in the product market. Then the game from the earlier sections, where the authority monitors after a costly report by the legal firm, is played. This innovation game can be summarised as follows:

**Stage 0:** The legal firm decides on the extent of R&D investment, $X$, where $\mu(X) \in [0,1]$ is the probability of the product being successfully developed. If the R&D investment is unsuccessful, the game stops.

**Stages 1 to 4:** If the product is successfully developed, then the pirate, the legal firm and the authority play the games that was discussed in the earlier sections for the two cases of price competition and quantity competition.

As before, let us solve the innovation game by backward induction. The results for stages 1-4 have already been derived in the earlier sections. Building on these results, I analyse the equilibrium for the initial innovation stage (stage 0) of the game. Let us look at the equilibrium conditions for the sub-game denoted by stages 1-4 for the two cases when i) the authority monitors under both price and quantity competitions and ii) the authority never monitors.

**Case 1:** $\alpha^*p, \alpha^*q > 0$.

In this case, the authority monitors piracy under both price and quantity competitions. The legal firm will not report for any $R$ such that $R < R^*p$ and $R < R^*q$, and the pirate will enter for any $F$ such that $F < F^*q$ and $F < F^*p$. In stage 0, the legal firm maximises its expected profit from investing in R&D. The legal firm can realise its expected profit from stage 4, $E\pi_1$, provided its R&D expenditure, $X$, in stage 0 develops the new product with probability $\mu(X)$. With probability $1 - \mu(X)$, the legal firm cannot develop the product and foregoes the cost

---

14 We are not considering the in-between cases where there is monitoring for one form of competition and no monitoring under the other form of competition.
of R&D. Thus the legal firm chooses the optimal level of investment $X$ that maximises its expected profit in stage 0 given by:

$$\mu(X)E\pi_1 + (1-\mu(X))c - X$$

or

$$\mu(X)E\pi_1 - X$$

or

$$\mu(X)(\alpha^*(2-R) + (1-\alpha^*)(\pi_1 - R)) - X. \quad (22)$$

From the first order conditions of maximising expected profit with respect to $X$, it can be seen that

$$\mu'(X^*) = \frac{1}{(\alpha^*(2-R) + (1-\alpha^*)(\pi_1 - R))} = \frac{1}{(\alpha^*(2-\pi_1) + (\pi_1 - R))} \quad (23)$$

where $\alpha^* = \alpha^{*p}$ and $\pi_1 = \pi_1^{*p}$ in case of price competition and $\alpha^* = \alpha^{*q}$ and $\pi_1 = \pi_1^{*q}$ for the case of quantity competition. Thus, if the firms were competing in price in the product market, then $\pi_1 = \pi_1^{*p} = \frac{(2+c)^2}{8(2-c)}$ and if they were competing in quantity, then $\pi_1 = \pi_1^{*q} = \frac{1}{2(1-c)(2-c)}$. Moreover, for $c > 0$, $\pi_1^{*q} > \pi_1^{*p}$. Hence, given $c = \tilde{c} > 0$ which implies that $\alpha^{*p} = \alpha^{*q} > 0$, it can be shown that $\mu'(X^{*p}) > \mu'(X^{*q})$. This, in turn, implies $X^{*q} > X^{*p}$.

**Proposition 8:** For a sufficiently high level of political influence of the legal firm and a critical degree of product substitutability $\tilde{c}$ for which the authority will choose to monitor piracy at the same rate under price and quantity competition, the optimal R&D investment by the legal firm will be higher under quantity competition than under price competition for.

That is, $X^{*q} > X^{*p}$ if $c = \tilde{c} > 0$ and $\alpha^{*p} = \alpha^{*q} > 0$.

**Case 2:** $\alpha^{*p}, \alpha^{*q} = 0$.

(i) If $F > F^{*p}$ and $F > F^{*q}$, then the pirate will never enter under any modes of competition and monitoring will not take place. The legal firm will have a
monopoly in the product market and will choose the optimal level of $X$ that maximises $\mu(X)2 - X$, implying that $\mu'(X^*) = \frac{1}{2}$.

(ii) If $F < F^*p$ and $F < F^*q$ then the pirate will always enter the market irrespective of the mode of competition in the product market. Moreover, if $R > R^*p$ and $R > R^*q$, then the legal firm will never report the pirate and hence there will be no monitoring by the authority. The legal firm will thus be acting as a Stackelberg leader in the product market and will choose the optimal level of $X$ that maximises $\mu(X)\pi_1 - X$ where $\pi_1 = \pi^*i$ in case of price competition and $\pi_1 = \pi^*q$ for quantity competition. The first order condition of expected profit maximisation with respect to $X$ gives $\mu'(X^*) = \frac{1}{\pi_1}$. If the firms were competing in price, then $\pi_1 = \pi^*i = \frac{(2 + c)^2}{8(2 - c)}$ and if they were competing in quantity, then $\pi_1 = \pi^*q = \frac{1}{2(1 - c)(2 - c)}$. For $c > 0$ and $\alpha^*p = \alpha^*q = 0$, we have $\pi^*q > \pi^*i$. Thus, $\mu'(X^*q) > \mu'(X^*i)$ implying that $X^*q > X^*i$.

Note that the monopoly profit of the legal firm is always higher than the profit under a Stackelberg duopoly for both price competition and quantity competition. That is, $\pi^*m = 2 > \pi^*_i$, where $\pi^*_i \in [\pi^*i, \pi^*q]$. Hence, $\mu'(X^*m) = \frac{1}{2} < \mu'(X^*) = \frac{1}{\pi^*_i}$, implying that $X^*m > X^*$ where $X^* \in [X^*i, X^*q]$. Thus investment in R&D by the legal firm is highest under monopoly and, when it competes with a pirate in the product market, it is higher under quantity competition than under price competition.
6. Conclusions

This paper investigates the decision of a regulatory authority to incur costs in monitoring commercial piracy after the legal firm has reported the presence of the pirate in the market. The existing literature on monitoring commercial piracy looks at the ex-ante monitoring strategies where the authority, with the objective of maximising ex-ante social welfare, sets and commits to a level of monitoring before the pirate enters the market. However, empirical evidences show that often the authorities take monitoring decisions ex-post after the legal firm has taken the initiative to report piracy. This study attempts to bridge this gap in the literature by analysing the ex-post monitoring decision of the authority when the legal firm undertakes a costly process of investigating and reporting piracy to the authority.

I examine the case where the objective of the regulatory authority is weighted by the political influence of the legal firm and the consumers. I find that the authority will monitor piracy under both price and quantity competition if the political influence of the legal firm is sufficiently high. I also show that there exists a unique level of product substitutability between the legal firm and the pirate above which monitoring will be higher under quantity competition and below which monitoring will be higher under price competition. This implies that the extent of political influence the legal firm will exert on the regulatory authority to induce monitoring depends crucially on the mode of competition and on the degree of product substitution.

The mode of competition and the degree of product substitution also affect R&D decisions of the legal firm in the presence of piracy. It can be seen that piracy unambiguously reduces R&D investment by the legal firm. However, the reduction in R&D is lower under quantity competition than under price competition. In other words, given the degree of product substitutability between the legal firm and the pirate, the legal firm will invest more under quantity competition than under price competition. The magnitude of the legal firm’s R&D investment would be determined by the closeness of its innovated product to the pirated
copy, the influence of the legal firm on the political objective of the monitoring authority and the mode of competition between the legal firm and the pirate.

Thus, this study explores how the degree of product substitutability and mode of competition affect the decisions by the legal firm to undertake R&D and to report the presence of piracy in the product market to the authority and also the decision of the authority to monitor piracy, once reported. However, I take the degree of product substitutability as exogenous in this study. An interesting extension of this work would be to endogenise the degree of product substitutability and examine how the pirate and the legal firm locate their products, given the market demand. Thus this study could add to the literature (for example, Choi and Coughan, 2006; Noh and Moschini, 2006) on quality or brand differentiation and label positioning by considering illegal brands and pirated labels in the product market. It would be interesting to examine how the legal firm and the pirate position their product qualities when they enter the market and how monitoring decision by the authority is affected by such endogenous product locations. A further extension would be to introduce uncertainty on the part of the consumers regarding product quality (see Metrick and Zeckhauser 1996) and examine how the equilibrium is affected if the consumer is unable to distinguish between the legal product and the pirated copy.

Another line of research could be to extend this study to investigate of how the authority’s monitoring decision and the legal firm’s R&D decision are influenced by the relative political influence of the legal firm and the pirate. That is, if the simplifying assumption of $\gamma = 0$ is removed to analyse the effect of the ratio of the political powers of the legal firm and the pirate, $\frac{\beta}{\gamma}$, in influencing the political objective and thereby the monitoring decisions of the regulatory authority. Thus, this study could be a step towards empirical and policy studies by bringing together the literature on innovation, product differentiation, commercial piracy and corruption.
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