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Collusion, competition and piracy^{*}

Francisco Martínez-Sánchez^{**}

Abstract

In this paper we analyze firms' ability to tacitly collude on prices in an infinitely repeated duopoly game of vertical product differentiation. We show that firms collude if and only if their discount factor is high enough, i.e. if they value future profits sufficiently. We also show that a lower cost of copying facilitates collusion but that a higher quality of the copy hinders collusion. Thus, the overall effect of these new characteristics of copies made by consumers is ambiguous.

Keywords: Collusion, competition, piracy, consumers, cost of copying, quality differential

JEL Classification: D40, K42; L13; L40; O34

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1 Introduction

It has recently been shown that prices are very important for deterring consumers from copying and from buying copies from illegal firms who illegally make and sell them, both empirically (Papadopoulos (2003)) and theoretically (Bae and Choi (2006) and Martínez-Sánchez (2007)),¹ and that competition drives prices up and may lead to price dispersion (Belleflamme and Picard (2007)). Price strategies thus become very important in markets for piratable goods. These results raise the question of whether firms might tacitly collude on prices in these markets. Moreover, the latest technological developments have enabled consumers to make better and cheaper copies of original information goods (Martínez-Sánchez (2008)), which raises the question of whether collusion is now more difficult or easier than previously.

In this paper we investigate firms' ability to tacitly collude on prices in an infinitely repeated duopoly game of vertical product differentiation. To that end we use the model developed by Belleflamme and Picard (2007). They consider that the copying technology exhibits increasing returns to scale, and they analyze the pricing behavior of a multiproduct monopolist and a duopolist in a model of vertical product differentiation, where there are two information goods which are perfectly (horizontally) differentiated and equally valued by users. Belleflamme and Picard show that in a monopoly equilibrium prices are neither unique nor symmetric, and that in a duopoly, when the cost of copying is high enough there is a symmetric equilibrium in pure strategies but when the cost of copying is low enough there is no equilibrium in pure strategies although there is a symmetric equilibrium in mixed strategies. They also show that the multiproduct monopolist has an incentive to set lower prices than the duopolist because it realizes that decreasing the price for one good increases demand for the other good by making copying less attractive. Finally, Belleflamme and Picard (2007) show that a multiproduct monopoly makes for greater welfare than a duopoly in the short run but provides lower incentives to create in the long run.

The fact that firms can collude in markets for vertically differentiated products has been analyzed by Häckner (1994). He assumes that each firm produces a variant of the same product and the production cost is zero. He finds that collusion is more easily sustained the more similar the products are, which contrasts with the results obtained in horizontal product differentiation models (Chang (1991) and Häckner (1996)). Recently, firms in markets for information goods have developed technological tools known as digital rights management (DRM) to prevent the copying of their goods. The cost of DRM systems can be shared among various firms, which have a collusive impact on prices according to Park and Scotchmer (2006).

Schultz (2005) analyzes the effect of increased consumer information about prices in the market on firms' ability to collude, and shows that collusion becomes harder to sustain when consumer information increases. On the other hand, Liu and Serfes (2007) obtain that collusion becomes more difficult as the quality of firms' information about consumers' preferences improves.

Bae and Choi (2006) investigate the role of the reproduction cost of copies made by consumers without

¹See Peitz and Waelbroeck (2006) for a survey of piracy in which copies are made exclusively by end consumers. However, there is another literature that analyzes the case of a single firm that illegally makes copies and sells them on the market, which is known as *commercial piracy* (Martínez-Sánchez (2007) and López-Cuñat and Martínez-Sánchez (2009)).

the authorization of producers. They assume that the reproduction cost is constant across consumers and find that an increase in the reproduction cost induces more authorized usage of the software but less total usage of the software, so it may increase or decrease social welfare in the short-run. Moreover, higher reproduction costs result in lower quality, which reduces social welfare in the long-run. Thus, an increase in the reproduction cost may reduce social welfare in the short-run and long-run.

In recent years the quality of copies has become closer to the quality of original information goods. López-Cuñat and Martínez-Sánchez (2009) prove that the initial quality differential between the original and the copy is critical. On the one hand, the standard wisdom showing that an increase in the quality of copy increases piracy should be reviewed. They show that this is a local conclusion because when the initial quality differential is low enough an increase in the quality of copies may deter commercial piracy. On the other hand, López-Cuñat and Martínez-Sánchez prove that the effects on the optimal monitoring rate which deters piracy depend on the initial quality differential. If it is low enough, an increase in the quality of the copy may decrease the optimal monitoring rate. Nevertheless, if it is high enough, a local increase in the quality of the copy may increase the optimal monitoring rate, but a non local increase may decrease it.

We show that firms collude if and only if their discount factor is high enough, i.e. if they value future profits sufficiently. We also show that a lower cost of copying facilitates collusion but that a higher quality of the copy hinders collusion. Thus, the overall effect of these new characteristics of copies made by consumers is ambiguous.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 obtains and analyzes the equilibrium. Section 4 concludes.

2 The model

Following Belleflamme and Picard (2007) we consider that there are two information goods which are perfectly (horizontally) differentiated and equally valued by consumers. Consumers are indexed by $\theta \in [\underline{\theta}, \bar{\theta}]$, with $\underline{\theta} > 0$, for any information good, where θ follows a uniform distribution and represents the consumers' tastes for the quality of the good. Information goods can be copied by consumers when they incur a fixed cost $K > 0$, so the copying technology exhibits increasing returns to scale. However, this technology provides a copy whose quality, s_c , is lower than that of the original information good, s_o , i.e. $0 < s_c < s_o$. We assume $\underline{\theta}s_c - K \geq 0$, so all consumers prefer copying a single good to not consuming any information goods. Thus, each consumer is assumed to obtain one unit of each good, by either buying it or copying it. Therefore, the utility of consumer θ is:

$$U(\theta) = \begin{cases} 2\theta s_o - p_1 - p_2 & \text{if he buys both goods} \\ \theta s_o + \theta s_c - p_i - K & \text{if he buys one good and copies the other} \\ 2\theta s_c - K & \text{if he copies both goods} \end{cases} \quad (1)$$

where p_i represents the price of the original information good $i = 1, 2$. By comparing the levels of utility obtained from each consumer's strategy we find the demand function for information good $i = 1, 2$:²

$$D_i(p_i, p_j) = \begin{cases} \frac{1}{\bar{\theta} - \underline{\theta}} \left(\bar{\theta} - \frac{p_i - K}{s} \right) & \text{if } p_j + K \leq p_i \\ \frac{1}{\bar{\theta} - \underline{\theta}} \left(\bar{\theta} - \frac{p_i + p_j - K}{2s} \right) & \text{if } p_j - K \leq p_i < p_j + K \\ \frac{1}{\bar{\theta} - \underline{\theta}} \left(\bar{\theta} - \frac{p_i}{s} \right) & \text{if } p_i < p_j - K \end{cases} \quad (2)$$

where $s = s_o - s_c$. According to Belleflamme and Picard, each segment of the demand function corresponds to a specific category of consumers: buyers, copiers and switchers. When $p_i \geq p_j + K$, consumers are *buyers* because they buy good j regardless of whether they buy or copy good i . When $p_i < p_j - K$, they are *copiers* because they copy good j whatever they decide about good i . Thus, in these two categories, the demand for good i does not depend on the price of good j . Finally, when $p_j - K \leq p_i < p_j + K$, consumers are *switchers* because they buy (copy) good j if they buy (copy) good i . Thus, the demand negatively depends on both prices, so in this range of prices the two goods are complementary.

Notice that information goods become complementary although they have independent content. This is because consumers are able to copy with a technology with increasing returns to scale. Finally, we assume that $\bar{\theta}s > \underline{\theta}(s + s_o)$, which means that in any demand regime firms never find it optimal to cover the whole market.

Following Friedman (1971), we consider an infinitely repeated game in which firms play trigger strategies. In particular, firms start by charging collusive prices and continue charging these prices if neither firm has deviated in a previous stage. However, if either firm deviates in a stage, then both firms revert to the Bertrand-Nash equilibrium in the following stages. We assume perfect monitoring, so if a firm has deviated it is immediately detected but the punishment is implemented in the following stage.

In the next section, we seek to find the subgame perfect equilibrium (SPE) of the infinitely repeated game.

3 Results

Let π_i^C , π_i^D and π_i^{B-N} be the one period collusion, deviation and Bertrand-Nash profits of firm $i = 1, 2$, respectively. Collusion on prices is an SPE of the game if and only if the present value of collusion profits exceeds the deviation profit plus the present value of the punishment profits of each firm, i.e. if and only if

$$\sum_{t=0}^{\infty} \delta^t \pi_i^C \geq \pi_i^D + \sum_{t=1}^{\infty} \delta^t \pi_i^{B-N} \quad \forall i = 1, 2, \quad (3)$$

where δ represents the discount factor. We assume that the production cost incurred by firms is zero. Given that firms are symmetrical, we focus on symmetric equilibrium. In order to make the paper more readable we eliminate subscript i on prices and profits. When firms collude on prices, they behave as a

²For a more detailed analysis see Belleflamme and Picard (2007).

multiproduct monopoly. From Belleflamme and Picard (2007), we have that firms price p^C and obtain the profit π^C in this case, where

$$p^C = \frac{2\bar{\theta}s + K}{4} \text{ and } \pi^C = \frac{(2\bar{\theta}s + K)^2}{16s}. \quad (4)$$

The punishment profits are the Bertrand-Nash profits corresponding to the duopoly equilibrium. Belleflamme and Picard (2007) show that, in duopoly, there exists a unique symmetric equilibrium in which both firms focus on switchers and price $p^{B-N} = (2\bar{\theta}s + K)/3$ if and only if $K > \hat{K} = (3\sqrt{2} - 4)\bar{\theta}s/2$. Otherwise, there is no equilibrium in pure strategies. In duopoly, the profit of each firm is

$$\pi^{B-N} = \frac{(2\bar{\theta}s + K)^2}{18s}. \quad (5)$$

Hence, we assume that $K > \hat{K}$, because we focus on pure strategy equilibria given the multiplicity and complexity of mixed-strategy equilibria.³ If a firm deviates from the collusive agreement, it prices according to its best-response function:⁴

$$p_i^{BR}(p_j) = \begin{cases} (\bar{\theta}s + K)/2 & \text{if } p_j \leq (\bar{\theta}s - K)/2, \\ p_j + K & \text{if } (\bar{\theta}s - K)/2 \leq p_j \leq (2\bar{\theta}s - K)/3, \\ \bar{\theta}s + (K - p_j)/2 & \text{if } (2\bar{\theta}s - K)/3 \leq p_j \leq (2 - \sqrt{2})\bar{\theta}s + K, \\ \bar{\theta}s/2 & \text{if } p_j \geq (2 - \sqrt{2})\bar{\theta}s + K. \end{cases} \quad (6)$$

Therefore, the optimal deviation price and profit are

$$p^D = \begin{cases} \frac{2\bar{\theta}s + 5K}{4} & \text{if } \hat{K} < K \leq 2\bar{\theta}s/7 \\ \frac{6\bar{\theta}s + 3K}{8} & \text{if } K \geq 2\bar{\theta}s/7 \end{cases} \quad (7)$$

$$\pi^D = \begin{cases} \frac{(2\bar{\theta}s + 5K)(2\bar{\theta}s - K)}{16s} & \text{if } \hat{K} < K \leq 2\bar{\theta}s/7 \\ \frac{(6\bar{\theta}s + 3K)^2}{128s} & \text{if } K \geq 2\bar{\theta}s/7 \end{cases} \quad (8)$$

When $K \geq 2\bar{\theta}s/7$, although the cheating firm deviates from the collusive agreement, it continues to accommodate switcher consumers. However, when the copying cost is low enough ($\hat{K} < K \leq 2\bar{\theta}s/7$), the cheating firm decides to concentrate on higher-value consumers (buyers) by increasing its price and avoid switchers. From inequality (3), collusion profit (4), duopoly profit (5) and the deviation profit (8), we find that firms decide to collude if and only if their discount factor is high enough.

Proposition 1 *Collusion is sustainable as an SPE if and only if*

$$\delta \geq \underline{\delta} = \frac{\pi^D - \pi^C}{\pi^D - \pi^{B-N}} = \begin{cases} \frac{18K(2\bar{\theta}s - 3K)}{4\bar{\theta}^2 s^2 + 40\bar{\theta}sK - 53K^2} & \text{if } \hat{K} < K \leq 2\bar{\theta}s/7 \\ \frac{9}{17} & \text{if } K \geq 2\bar{\theta}s/7, \end{cases}$$

where $\underline{\delta}$ represents the lowest discount factor that is needed to sustain collusion between firms.

³Belleflamme and Picard (2007) find a mixed-strategy equilibrium when $\tilde{K} = 0.0274\bar{\theta}s < K < \hat{K}$.

⁴See Belleflamme and Picard (2007).

The new characteristics of copies made by consumers have two opposing effects on firms' ability to collude in markets for information goods: on the one hand, the quality of copies is becoming closer and closer to that of the original good, which hinders collusion; on the other hand, the cost of copying is low and is decreasing over time, which facilitates collusion. Thus, the overall effect is ambiguous. Therefore, authorities should pay special attention in these markets to prevent tacit collusion. These results are extracted from the following proposition.

Proposition 2 *When $\hat{K} < K \leq 2\bar{\theta}s/7$, $\underline{\delta}$ is increasing on the cost of copying, K , but is decreasing on the degree of differentiation, s , and on the maximal willingness to pay for quality on the part of consumers, $\bar{\theta}$. However, when $K \geq 2\bar{\theta}s/7$, the effect of s , K and $\bar{\theta}$ on $\underline{\delta}$ is null.*

Proof: see Appendix.

A surprising result is that collusion is more difficult to sustain when the quality of the copy is more similar to that of the original good, which contrasts with the results of Häckner (1994), who finds that collusion is more easily sustained the more similar the products are. However, it is in keeping with those results obtained in horizontal product differentiation models (Chang (1991) and Häckner (1996)). This is because we consider that there are two information goods that are horizontally differentiated although they can be copied with a lower quality. In vertical differentiation models high-quality firm has weak incentives to collude when products are very different, but in horizontal differentiation models both firms are identical and deviation profits are lower when differentiation increases (Chang (1991), Häckner (1994) and Häckner (1996)).

Unfortunately, given the non existence of equilibria in pure strategies when the copying cost is very low, we cannot supply a conclusion in the limit case in which $K = 0$ for a positive value of s . However, as $s \rightarrow 0$, we get that the lowest discount factor that is needed to sustain collusion is independent of K since $\lim_{s \rightarrow 0} \underline{\delta} = 9/17$. Thus, as the quality of the copy is very close to that of the original good, copying costs have no effect on the ability of firms to collude.

4 Conclusions

In this paper we analyze firms' ability to collude in markets for information goods and the consequences of lower copying costs and a higher copy quality on that ability in an infinitely repeated duopoly game of vertical product differentiation with price competition.

According to our model firms tacitly collude if and only if they value future profits sufficiently, and the new characteristics of pirated copies have two opposing effects on firms' ability to collude: on the one hand, copies are ever closer in quality to the original good, which hinders collusion; on the other hand, the cost of copying is low and is decreasing over time, which facilitates collusion. Thus, the overall effect of these new characteristics of copies made by consumers is ambiguous. Therefore, authorities should pay special attention in markets for information goods to prevent tacit collusion between firms, so as not to harm the financial incentives of creators.

Appendix

Proof of Proposition 2. When $\hat{K} < K \leq 2\bar{\theta}s/7$, we have

$$\begin{aligned}\frac{\partial \underline{\delta}}{\partial s} &= \frac{-36\bar{\theta}K(2\bar{\theta}s - 7K)(2\bar{\theta}s + K)}{(4\bar{\theta}^2s^2 + 40\bar{\theta}sK - 53K^2)^2} < 0 \\ \frac{\partial \underline{\delta}}{\partial K} &= \frac{36\bar{\theta}s(2\bar{\theta}s - 7K)(2\bar{\theta}s + K)}{(4\bar{\theta}^2s^2 + 40\bar{\theta}sK - 53K^2)^2} > 0 \\ \frac{\partial \underline{\delta}}{\partial \bar{\theta}} &= \frac{-36sK(2\bar{\theta}s - 7K)(2\bar{\theta}s + K)}{(4\bar{\theta}^2s^2 + 40\bar{\theta}sK - 53K^2)^2} < 0.\end{aligned}$$

■

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