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Tacit Collusion with Consumer Preference Costs

Guillem Roig[1]

Abstract

When consumers have preference costs, two opposing effects need to be assessed to analyze firms' incentives to set collusive prices. On the one hand, preference costs make a deviation from collusion less attractive, as the deviating firm must offer a steeper discount to cover these preference costs. On the other hand, preference costs lock in consumers and make punishment from rivals less effective. When preference costs are low, the second effect dominates and collusion is harder to sustain than in a situation with no preference costs. The contrary happens with high enough preference costs.

Keywords: Tacit Collusion; Consumer Preference Costs.

JEL classification: D43; L13; L12.

1. Introduction

Starting with Chamberlain [1929], several authors have studied the factors that may facilitate or hinder collusion among competing firms (e.g. detection lags, market asymmetries, multimarket contacts (see Tirole [1988])). However, little is known about the firms' abilities to sustain collusion in relation to differing consumer characteristics.[2] I consider a duopoly competition model in which consumers have preference costs, i.e., they have a utility loss if they buy their least preferred product. Preference costs makes the study of tacit collusion among the firms interesting. Preference costs make a deviation from collusion less attractive, when a firm deviates from the collusive outcome it needs to undercut the price to compensate for the preference costs. However, preference costs lock in consumers and make punishment from rivals less effective; firms obtain positive expected profits after deviation, and those profits increase with preference costs. While the first effect (stepper price discount) makes collusion easier to sustain, the second effect (milder punishment after deviation) does the opposite.

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[2]Roig [2019] studies how consumer concentration impacts the possibility of collusive price setting in markets with switching costs. Padilla [1995] analyzes firms' collusion in an overlapping generation model with consumer switching costs. Deneckere (1983) studies the equilibrium of supergames with product differentiation and shows that when product differentiation is large enough tacit collusion is easier to sustain with quantity rather than price competition.

I find a non-monotone relationship between the level of consumer preference costs and the firms' abilities to collude. For a small level of consumer preference costs, collusion is harder to sustain compared to a situation with no consumer preferences; the decrease in the severity of punishment after deviation dominates the price cut needed to compensate for consumer preferences. However, when consumer preference costs are large, the effect on the price cut to attract rival consumers dominates and collusion is always an equilibrium. Therefore, a competition authority should consider the effects of consumer preference costs when studying the likelihood of collusive agreements.

2. Model

I study a model between two symmetric firms ($i = A, B$) that sell a non-durable good over an infinite number of periods to consumers who have preference costs. There is a mass two of consumers with inelastic demand for one unit of the good with the reservation utility equal to 1. Consumers' preference costs mean that a consumer only obtains the reservation utility of 1 after the purchase of his or her most preferred good, purchasing the other good generates a loss of $S \in (0, 1]$. I assume that half of the consumers have a preference for the good offered by one of the firms and the other half have a preference for the good offered by the other. All firms are risk-neutral neutral and discount future profits by the discount factor $\delta \in [0, 1]$.

Each period t is composed of two stages. In Stage 1, both firms announce a price. I assume that only short-term contracts are used and price discrimination based on purchasing histories is not possible. In Stage 2, consumers choose the firm from which to purchase the good. I assume that consumer preference costs are fixed over time and consumers do not behave strategically but make their purchasing decisions to maximize their stage utility.

For the study of collusive equilibrium, I consider trigger strategies in which firms quote the same collusive price $p^c \in (0, 1]$ in all periods until a deviation occurs, from which time on they will revert to the competitive mode permanently. Finally, when consumers are indifferent between which good to purchase I do not assume any specific tie-breaking rule and show that the firms' expected profits depend on the consumers' purchasing decisions when indifferent.

3. Analysis

For the study of firms' abilities to collude, I first characterize the punishment path after deviation. Later, I analyze under which conditions the firms will sustain a collusive price agreement.

3.1. Punishment path

If $|p_1 - p_2| < S$, consumers buy from the firm whose product they prefer. Otherwise, all the consumers buy from the lowest price firm. Because the payoff functions of the firms are discontinuous, there is no pure strategy equilibrium (Dasgupta and Maskin [1986]). Letting $F(p)$ be the distribution of prices, the firms' expected profit is:

$$V = p \times \underbrace{[F(min\{p+S,1\}) - F(max\{0,p-S\})]}_{\text{Sells to consumers with its product preference}} + 2p \times \underbrace{[1 - F(min\{p+S,1\})]}_{\text{Sells to all the market}}. \tag{3.1}$$

The next lemma presents the firms' mixed strategy equilibrium and the profits of the stage game.

Lemma 1. *In the Nash equilibrium:*

i) For high consumer preference costs, $S \geqslant 1/2$, each firm sets the monopoly price $p = 1$, consumers always buy their most preferred good, and firms' obtain $V = 1$.

ii) For $S \in \left(0, 1/(2+\sqrt{2})\right]$, firms randomize over prices with the distribution function:

$$F(p) = \begin{cases} 0 & \text{if } p < \sqrt{2}S, \\ 1 - \frac{(1+\sqrt{2})S}{p+S} & \text{if } \sqrt{2}S \leqslant p < \left(1+\sqrt{2}\right)S, \\ 2 - \frac{(1+\sqrt{2})S}{p-S} & \text{if } \left(1+\sqrt{2}\right)S \leqslant p \leqslant \left(2+\sqrt{2}\right)S, \\ 1 & \text{if } p > \left(2+\sqrt{2}\right)S, \end{cases} \tag{3.2}$$

consumers buy the less preferred good with positive probability and firms obtain $V(S) = \left(1+\sqrt{2}\right)S$.

iii) For $S \in \left(1/(2+\sqrt{2}), 1/2\right)$, when consumers buy the most preferred good when indifferent, firms randomize over prices with the distribution function:

$$\sigma^I = F(p) = \begin{cases} 0 & \text{if } p < \frac{-S+\sqrt{S(4+S)}}{2}, \\ 1 - \frac{S+\sqrt{S(4+S)}}{2(p+S)} & \text{if } \frac{-S+\sqrt{S(4+S)}}{2} \leqslant p < 1-S, \\ 1 - \frac{S+\sqrt{S(4+S)}}{2} & \text{if } 1-S \leqslant p < \frac{S+\sqrt{S(4+S)}}{2}, \\ 2 - \frac{S+\sqrt{S(4+S)}}{2(p-S)} & \text{if } \frac{S+\sqrt{S(4+S)}}{2} \leqslant p < 1, \\ 1 & \text{if } p \geqslant 1, \end{cases} \tag{3.3}$$

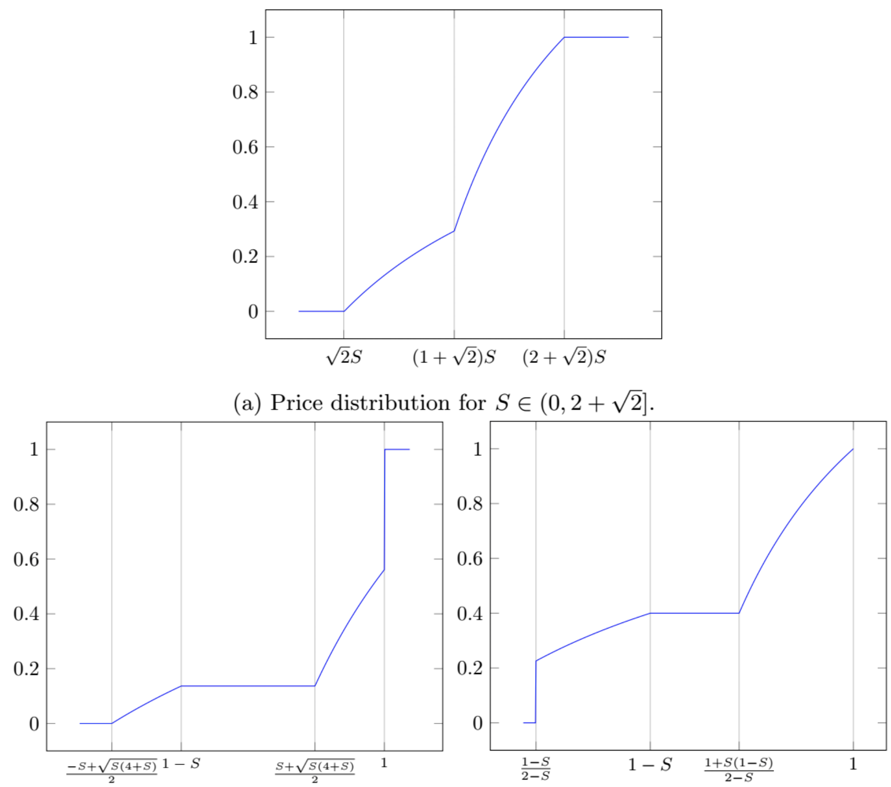
and, when consumers buy the less preferred good when indifferent, with the distribution function:

$$\sigma^{II} = F(p) = \begin{cases} 0 & \text{if } p < \frac{1-S}{2-S}, \\ 1 - \frac{1-S}{p+S} & \text{if } \frac{1-S}{2-S} \leqslant p < 1-S, \\ S & \text{if } 1-S \leqslant p < \frac{1+S(1-S)}{2-S}, \\ 2 - \frac{1-S}{p-S} & \text{if } \frac{1+S(1-S)}{2-S} \leqslant p < 1. \\ 1 & \text{if } p \geqslant 1, \end{cases} \tag{3.4}$$

In both cases, consumers buy the less preferred good with positive probability and firms obtain $V(S) = \left(S + \sqrt{S(4+S)}\right)/2$ *when they play* σ^I*, and* $V(S) = 1 - S$ *when they play* σ^{II}*.*

Proof. See the Appendix. □

Figure 1 presents the distribution function $F(p)$ for different values of consumer preference costs. With small preference costs, $S \in \left(0, 1/(2+\sqrt{2})\right]$, the distribution function is atomless, and no firm



(a) Price distribution for $S \in (0, 2+\sqrt{2}]$.

(b) Price distribution for $S \in (2+\sqrt{2}, 1/2)$ with a mass point at the upper-bound of the support (equilibrium σ^I).

(c) Price distribution for $S \in (2+\sqrt{2}, 1/2)$ with a mass point at the lower-bound of the support (equilibrium σ^{II}).

Figure 1: Price distribution as function of consumer preference costs.

plays with positive probability any price belonging to in the support of the price distribution [see part (a) in the figure]. For larger consumer preference costs $S \in \left(1/(2+\sqrt{2}), 1/2\right)$, the upper bound of the distribution function reaches the consumers' reservation price and there must be an atom in the support of prices. In which part of the support firms play positive probability depends on the consumers' purchasing decisions when they are indifferent between the goods to buy. If consumers buy their most preferred good, firms behave less aggressively and play the upper bound of the support with a positive probability [see part (b) in the figure]. Conversely, if consumers buy the less preferred good, firms behave more aggressively and play with positive probability at the lower bound of the support [see part (c) in the figure].

3.2. Collusive equilibrium

When static games are infinitely repeated, firms may settle at a cooperative price, even without explicitly colluding (Friedman [1971]). Tacit collusion is an equilibrium if no firm deviates from the collusive agreement, and this occurs whenever:

$$\Pi_i \left(p^c, p^c\right) \geqslant \pi_i \left(p_i^d, p^c\right) + \delta \Pi_i \left(F(p)\right) \qquad \forall i = A, B. \tag{IC_f}$$

The left-hand side is the present value of the firm's profit where it to remain in the collusive price $p^c \in (0,1]$, and the left-hand side is the present value of the profit to a firm that undercuts the collusive price by posting a price p_i^d, then, $\pi_i\left(p_i^d, p^c\right)$ is the profit for the deviating firm at the moment of deviation, and $\delta\Pi_i(F(p))$ is the discounted expected profit of the continuation game obtained in the Nash reversion. A price arbitrarily close to $p_i^d = p^c - S$ makes all consumers buy the product from the deviant firm and condition (IC_f) becomes:

$$\frac{p^c}{1-\delta} \geqslant 2 \times (p^c - S) + \left(\frac{\delta}{1-\delta}\right) V(S). \tag{3.5}$$

The next proposition establishes when a collusive agreement is implemented.

Proposition 1. *The firms' abilities to collude depend on the preference costs and the discount factor.*
i) Without preference costs, collusion is an equilibrium if $\delta \geqslant 1/2$.
ii) For $S \in \left(0, 1/(2+\sqrt{2})\right]$*, collusion is an equilibrium if* $\delta \geqslant (p^c - 2S))/\left(2p^c - (3+\sqrt{2})S\right)$.
iii) For $S \in \left(1/(2+\sqrt{2}), 1/2\right)$*, in equilibrium* σ^I*, if* $\delta \geqslant (2(p^c - 2S)) / \left(4(p^c - S) - (S + \sqrt{S(4+S)})\right)$*, and in equilibrium* σ^{II}*, if* $\delta \geqslant (p^c - 2S)/\left(2p^c - (1+S)\right)$*, collusion is an equilibrium.*
iv) For $S \geqslant 1/2$*, collusion is always an equilibrium.*

Proof. We establish the conditions under which Expression (3.5) is satisfied.

- $S = 0$. A deviating firm undercuts the price only slightly, and no profits are made after deviation. A collusive price is an equilibrium for $\delta \geqslant 1/2$.

- $S \in \left(0, 1/(2+\sqrt{2})\right]$. The stage expected profit is $V(S) = \left(1+\sqrt{2}\right) S$, and collusion is an equilibrium if

$$\frac{p^c}{1-\delta} \geqslant 2 \times (p^c - S) + \delta \left(\frac{(1+\sqrt{2})S}{(1-\delta)}\right) \Longleftrightarrow \delta \geqslant \frac{p^c - 2S}{2p^c - (3+\sqrt{2})S}.$$

- $S \in \left(1/(2+\sqrt{2}), 1/2\right)$. In equilibrium σ^I firms obtain $V(S) = \left(S + \sqrt{S(4+S)}\right)/2$, and collusion is an equilibrium if

$$\frac{p^c}{1-\delta} \geqslant 2 \times (p^c - S) + \frac{\delta(S + \sqrt{S(4+S)})}{2(1-\delta)} \Longleftrightarrow \delta \geqslant \frac{2(p^c - 2S)}{4(p^c - S) - (S + \sqrt{S(4+S)})}.$$

In equilibrium σ^{II} firms obtain $V(S) = 1 - S$, and collusion is an equilibrium if

$$\frac{p^c}{1-\delta} \geqslant 2 \times (p^c - S) + \delta\left(\frac{1-S}{1-\delta}\right) \Longleftrightarrow \delta \geqslant \frac{p^c - 2S}{2p^c - (1+S)}.$$

- $S \geqslant 1/2$. No firm attracts the consumer whose product preference is for the rival good, and collusion is an equilibrium.

□

Figure 2 illustrates the results when the firms set the collusive price $p^c = 1$ that maximize the profits that firms could earn by cooperating. The blue shaded area represents the region of a

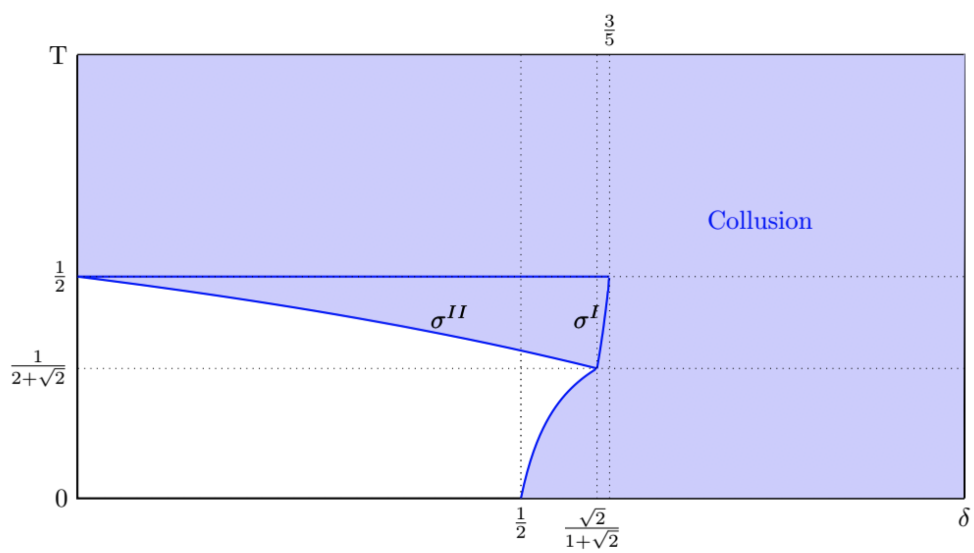


Figure 2: Region for full collusion.

collusive agreement. When consumers do not have preference costs, a deviating firm undercuts the price slightly and sells to all consumers. Then, retaliation begins, but since firms sell a homogenous good, no profits arise. Thus, collusion is an equilibrium for sufficiently patient firms, i.e., $\delta \geqslant 1/2$ (the same result occurs in a simple model of duopoly competition (see Tirole [1988])). With preference costs, the relationship between consumer preference costs and the prevalence of collusion is non-monotonic. With small preference costs, an increase in the costs makes collusion more difficult to implement, but with $S \geqslant 1/2$, collusion always occurs since neither firm finds it profitable to attract the consumers of the rival. For small preference costs, there is a trade-off in the implementation of a collusive equilibrium. Preference costs reduce the benefits at the moment of deviation; the deviating firm must pay those costs to attract the rival's customers. However, preference costs also reduce the severity of the punishment; consumers are locked in, and competition with homogenous goods generates positive profits. The expected profits in the punishment path are $V(S) = (1 + \sqrt{2})S$ for $S \leqslant 1/(2 + \sqrt{2})$ and $V(S) = (S + \sqrt{S}(S+4))/2$ for $S \in \big(1/(2+\sqrt{2}), 1/2\big)$. The reduction in the severity of the punishment dominates, and collusion is harder to implement. This result does not eventuate when consumers buy their less preferred good when indifferent. An increase in consumer preference costs makes the punishment after deviation more severe ($V(S) = 1 - S$), and because the price cut moves in the same direction, collusion is easier to sustain.

Corollary 1. *When indifferent consumers buy their less preferred goods, the collusive outcome is easier to sustain than when indifferent consumers buy their most preferred goods.*

The understanding consumer characteristics is important when determining the incentives of firms to collude. With small preference costs, collusion is harder to sustain than without preference costs, but with large preference costs, collusion becomes easier. Therefore, a competition authority need not devote resources to fighting collusion in markets with small consumer preference costs; rather, they should monitor markets where consumer preference costs are important.

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Appendix

Proof of Lemma 1: Rearranging equation (3.1) gives:

$$\frac{V}{p} = 2 - [F(min\{p+S, 1\}) + F(max\{0, p-S\})]. \tag{3.6}$$

To characterize the function $F(p)$ I assume that the difference in the bounds for the support of $F(p)$ is less than two times the level of the consumer preference costs, $\bar{p} - \underline{p} \leqslant 2S$.[3] This formulation allows us to construct the distribution function $F(p)$ for prices belonging to different ranges. Then:

$\underline{p} + S \leqslant p < \bar{p}$. With this price $F(\min\{p+S, 1\}) = 1$ and $F(max\{0, p-S\}) = F(p-S)$. The right-hand side of (3.6) reduces to $F(p-S) = 1 - V/p$. Then, $F(p) = 1 - \frac{V}{p+S}$ for $\underline{p} \leqslant p < \bar{p} - S$.

$\underline{p} \leqslant p < \bar{p} - S$. With this price $F(\max\{0, p-S\}) = 0$ and $F(\min\{p+S, 1\}) = F(p+S)$. The right-hand side of (3.6) reduces to $F(p+S) = 2 - V/p$. Then, $F(p) = 2 - \frac{V}{p-S}$ for $\underline{p} + S \leqslant p < \bar{p}$.

$\bar{p} - S \leqslant p < \underline{p} + S$. The difference between any price belonging to this range and any point in the support is lower than the consumer preference costs. Setting this price, firms sell to those consumers who have a preference for their good. Then, $F(p) = 1 - \frac{V}{\bar{p}}$ for $\bar{p} - S \leqslant p < \underline{p} + S$.

Combining the previous results gives:

$$F(p) = \begin{cases} 0 & \text{if } p < \underline{p}, \\ 1 - \frac{V}{p+S} & \text{if } \underline{p} \leqslant p < \bar{p} - S, \\ 1 - \frac{V}{\bar{p}} & \text{if } \bar{p} - S \leqslant p < \underline{p} + S, \\ 2 - \frac{V}{p-S} & \text{if } \underline{p} + S \leqslant p \leqslant \bar{p}, \\ 1 & \text{if } p > \bar{p}. \end{cases} \tag{3.7}$$

If no firm plays with a positive probability the lower and the upper bound of the support, a firm sells to the consumers with preference for its good by setting a price $p = \underline{p} + S$. This gives an expected payoff of $V(S) = \underline{p} + S$ and the condition $\underline{p} = V - S$. The same occurs by setting a price $p = \bar{p} - S$, which generates an expected payoff of $V(S) = \bar{p} - S$ and the condition $\bar{p} = V + S$. Combining both

[3] In a model of switching costs, Shilony (1977) shows that there cannot be an equilibrium with a range in the support for $F(p)$ greater than twice the level of the switching costs.

expected profits gives $\bar{p} - \underline{p} = 2S$, and introducing this into (3.7) generates:

$$F(p \mid T) = \begin{cases} 0 & \text{if } p < \underline{p}, \\ 1 - \frac{\underline{p}+S}{p+S} & \text{if } \underline{p} \leqslant p < \underline{p} + S, \\ 2 - \frac{\underline{p}+S}{p-S} & \text{if } \underline{p} + S \leqslant p \leqslant \underline{p} + 2S, \\ 1 & \text{if } p > \underline{p} + 2S. \end{cases} \tag{3.8}$$

To define the bounds of the distribution, by setting a price $p = \underline{p} + 2S$, a firm does not sell to any consumers when the competitor sets a price arbitrarily below $\underline{p} + S$, this happens with probability $(\underline{p} - S)/\underline{p}$, and the firm obtains an expected payoff of $V = (\underline{p} + 2S) \times \left(1 - (\underline{p} - S)/\underline{p}\right) \iff (\underline{p} + 2S) \times S/\underline{p} = V$. Because $V = \underline{p} + S$, then $(\underline{p} + 2S) \times S/\underline{p} = \underline{p} + S$, which gives $\underline{p} = \sqrt{2}S$. Introducing this into (3.8) characterizes the equilibrium price distribution in Expression (3.2) stated in the lemma and the firm obtains expected profits of $V = \left(1 + \sqrt{2}\right) S$.

The upper bound of the support increases with the level of consumer preference costs, and an atomless distribution function expressed in (3.2) in the lemma is only valid for $S \in \left(0, 1/(2 + \sqrt{2})\right]$. Then, for $S \in \left(1/(2 + \sqrt{2}), 1/2\right)$, we have $\bar{p} = 1$ and the distribution function is:

$$F(p) = \begin{cases} 0 & \text{if } p < \underline{p}, \\ 1 - \frac{V}{p+S} & \text{if } \underline{p} \leqslant p < 1 - S, \\ 1 - V & \text{if } 1 - S \leqslant p < \underline{p} + S, \\ 2 - \frac{V}{p-S} & \text{if } \underline{p} + S \leqslant p \leqslant 1, \\ 1 & \text{if } p > 1. \end{cases} \tag{3.9}$$

We proceed to show that, depending on the consumers' purchasing decisions when they are indifferent between which good to purchase, firms play with positive probability a different point belonging in the support of the price distribution. Then, if consumers buy their most preferred goods when indifferent, firms never play the lower bound of the support with positive probability (a firm never sells to all of the consumers if the rival sets a price $p = \underline{p} + S$). Then, it has to be that $\underline{p} = V - S$. If firms play the upper bound of the support with zero probability, then $V(S) = 1 - S$. In this case, there must be an atom at $\underline{p} + S$ equal to $A(\underline{p} + S) = (1 - 2S(2 - S))/(1 - 2S)$. However, for $S \in \left(1/(2 + \sqrt{2}), 1/2\right)$, the atom is negative, and a contradiction ensures. Therefore, there must be an atom at the upper bound of the support equal to $A(1) = (S - 1 + V)/(1 - S)$. Because, firms do not play with positive probability at $\underline{p} + S$, we have $1 - V = 2 - V/(V - S) \iff V = (S + \sqrt{S(4 + S)})/2$, and the price distribution function $F(p)$ is the one characterized in Expression (3.3) in the lemma.

If consumers buy their less preferred goods when indifferent, firms never play the upper bound of the support with positive probability (a firm loses the consumers who prefer its good if the rival sets a price $p = \bar{p} - S$). If firms do not play with positive probability the lower bound of the support, we reach the same contradiction as in the previous paragraph, then, there must be an atom at the lower bound of the support equal to $A(\underline{p}) = (\underline{p} + 2S - 1)/(\underline{p} + S)$. When a firm sets a price equal to $p = \underline{p} + S$ it sells to the consumers with preference for its product only with probability $(1 - A(\underline{p}))$. Then, the expected profit is equal to $V = (\underline{p} + S) \times \big(1 - A(\underline{p})\big) \iff V = (\underline{p} + S) \times \big(1 - (\underline{p} + 2S - 1)/(\underline{p} + S)\big) = 1 - S$, and the price distribution function $F(p)$ is the one characterized in Expression (3.4) in the lemma.