# Coupons and Oligopolistic Price Discrimination

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*Publication date:*
1994

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# Discussion paper



TILBURG UNIVERSITY

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Center
for
Economic Research

No. 9412

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January 1994

ISSN 0924-7815

# COUPONS AND OLIGOPOLISTIC PRICE DISCRIMINATION

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**Abstract**

*This paper studies sales promotion through coupons in an oligopolistic market. Sending out coupons allows the sellers to separate market segments with different degrees of consumer brand loyalty. This kind of price discrimination is profitable for the individual seller when the cost of couponing is sufficiently low. In equilibrium, however, couponing increases competition and reduces profits. The paper provides comparative statics results and studies welfare implications.*

*Keywords:* Advertising, Coupons, Oligopoly, Price Discrimination; *JEL Classification No.:* D43, D83

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# 1 Introduction

This paper studies sales promotion through coupons and rebates in an oligopolistic industry. Sales promotion is a complementary, and in cases even more important marketing strategy than media advertising for a firm to increase its market share. Coupons and rebates count for the bulk of billion of dollars spent each year on these promotional activities. Manufacturers in the US distributed 310 billion coupons in 1992, representing an 6% increase over the year before (see Hume (1993)). Rebates are virtually equivalent to coupons except that they impose some additional redemption cost on the customer, namely the cost of mailing and waiting for the cash refund. For our purposes coupons and rebates play the same role and we will treat them interchangeably in our analysis.

We investigate the role of coupons in a market that is segmented due to location, brand loyalty, or access to product information. By offering a rebate, a manufacturer is able to attract some consumers who are otherwise more inclined to buy a competing brand. Consumers differ in their degree of brand loyalty. In the location interpretation of our model, they have different transportation costs. Sending out coupons is costly for the seller, and this cost increases as he targets to reach a higher percentage of the competing brand's consumers. By price discriminating between his own customers and the clientele of competing manufacturers, the seller can increase his own market share. We study the optimal marketing behaviour of the oligopolists in a game where prices, coupon values, and the levels of coupon distribution are chosen simultaneously. We restrict our analysis to the case where consumers are fully informed about all prices.

An empirical illustration of how firms use coupons to expand their market share is the classic struggle between *P&G*-Folger and the General Foods Corporation. Before Folger was acquired by *P&G* in 1963, it operated mainly west of the Mississippi where it had a leading share in the local coffee industry. In 1972 and 1973 Folger moved into Cleveland and Philadelphia with an advertising campaign that included sending 25 cents off coupons to more than a million households. The Maxwell House Division of General

Foods reacted by mailing 50-cent coupons to households in Cleveland. Later, similar counter-attacks were launched when *P&G* entered other markets in the East. Overall, General Foods succeeded in defending its market, but at a high cost.

With couponing the manufacturer has at least partial control of the type of household reached. Thus he is able to offer a reduced price to a specific segment of the market. Coupons can serve as a price discrimination device. Only those consumers who have received a coupon are able to benefit from the rebate. Since this enables the manufacturer to separate market segments, coupons are more than just a low price offered to all consumers. An alternative explanation of coupons has been proposed by Cremer (1984) and Caminal and Matutes (1990). In these models, coupons create a lock-in effect because the consumer is offered a rebate on future purchases of the product. The seller can stabilize his market share by creating an artificial cost of switching suppliers. This is in direct contrast with our model, where coupons tend to make switching more attractive. Yet another explanation (Gerstner and Hess (1991)) is that the seller can motivate retailer participation in the sales promotion by offering rebates to the consumers.

The literature on the price discrimination aspects of coupons is rather scarce. Narasimhan (1984) studies the consumers' decision to use a coupon. Only consumers with a sufficiently low opportunity cost of time take advantage of coupons. Thus price discrimination can be achieved through self-selection. Caminal and Matutes (1990) is, to our knowledge, the only study of oligopolistic behaviour, but in a repeat purchase context. In their model the consumer receives a rebate only after purchasing a second unit from the same seller. The role of coupons is to create a switching cost in the second period. If the firms precommit to a discount, competition in that period is decreased and the equilibrium profits increase.

In contrast, in our model coupons increase competition between firms. Each individual seller has an incentive to reduce the brand loyalty of the other firms' clientele in order to increase his market share. But, offering a rebate amounts to reducing the consumers' switching cost and so competition is intensified. In equilibrium, each seller's profits are lower than if coupons or price discrimination were not allowed. Price discrimination in combination with oligopolistic competition leads to lower prices; the consumers as a whole are better off when the sellers compete by using coupons.

The finding that firm profits may be lower as a result of price discrimination is similar to the findings of Thisse and Vives (1988). They show that discrimination is a dominant strategy for each firm. Yet, it leads to lower profits than a uniform price. Levy and Gerlowski (1991) show that "meeting competition clauses", whereby a seller announces to meet the competitor's price, may reduce equilibrium profits. One may view such clauses as a special type of coupon; they allow the seller to discriminate between those consumers who only receive his own ad and those who receive ads also from other firms.

In our model the manufacturers use coupons as long as the marginal cost of distributing coupons are not too high. Under certain assumptions on distribution costs, there is a unique symmetric equilibrium. In this equilibrium, as couponing becomes more expensive, the firms' profits increase, while consumer welfare decreases. This is so because a higher cost of price discrimination reduces competition between the firms. The sellers' profits increase and consumer welfare decreases also when the consumers become more heterogeneous. The intuition is that a higher degree of brand loyalty reduces the firms' incentive to use coupons as a discrimination device, which in turn leads to higher average prices for the consumers.

The following Section presents a simplified example, where we abstract from the costs of issuing coupons and from differences in the consumers' degree of brand loyalty. Section 3 describes the general model. We study the equilibrium marketing behaviour of the firms in Section 4. Section 5 provides some comparative statics and welfare results. All proofs are relegated to an Appendix.

# 2 An Example

To illustrate the main features of our analysis, we first present a simplified example of the more general model studied in the following sections. We study a duopoly market characterized by some segmentation according to location, brand loyalty, or access to product information. Using the language of the locational application, the model considers the following situation: There are two sellers, $A$ and $B$, located in different neighbourhoods of some geographical market. The sellers' production costs are normalized to zero. In each locality, there is a unit mass of consumers with a totally inelastic demand for one unit of the good for all prices between zero and $v > 0$. When a consumer purchases the good from the seller in the distant location, he has to pay a transportation cost $s < v$.

Shilony (1977) studies the equilibrium of this market when the sellers compete by setting prices in a standard Bertrand fashion. If $v \leq 2s$, both sellers will post the price $p^* = v$ in equilibrium. Undercutting the competitor's price is not profitable since this would yield a profit of at most $2(v - s) \leq v$. The price setting game between the duopolists fails to have a pure strategy equilibrium if $v > 2s$. Indeed, any combination of prices $(p_A, p_B)$ would allow one of the two sellers to gain either by undercutting the other seller or by increasing his price by some small amount. Shilony (1977) shows that that there is a unique symmetric mixed strategy solution where each seller gains an expected profit higher than $s$.

We now introduce oligopolistic price discrimination. Even though the seller is unable to identify the origin of the customers at his store, he can separate them through coupons. Each seller is able to offer the good at different prices in the two regions by mailing coupons to the other region. Coupons entail a legally binding promise by the seller to offer a rebate upon presentation. In our example, we abstract from mailing costs and assume that seller $i$ can costlessly send coupons to all consumers in region $j$. The coupon entitles its owner to buy the good from seller $i$ at the price $p_i - r_i$, while buyers without a coupon have to pay $p_i$.

In this simple example, competition between the duopolists, $A$ and $B$, results in the following equilibrium outcome:

$$p_A^* = p_B^* = p^* = s, \quad r_A^* = r_B^* = r^* = s. \tag{1}$$

Each consumer is indifferent between buying the good from seller $A$ or seller $B$. If he buys at the neighbouring store, has to pay the price $p^* = s$; otherwise, has to pay $p^* - r^* = 0$ but incurs the transportation cost $s$. In equilibrium, it must be the case that each consumer buys at the local store. If not, the local seller would have an incentive to lower his price slightly below $s$. Clearly, the outcome described by (1) constitutes an equilibrium: By charging a price above $s$ a seller would lose all his customers. Charging a price below $s$ can never be optimal, since each seller enjoys a local monopoly position for all prices up to $s$. Actually, the equilibrium is unique: If some seller $i$ would charge a price $p_i > s$, then the opponent could induce all consumers in region $i$ to switch by offering $p_j - r_j$ slightly below $p_i - s$. Accordingly, a price $p_i > s$ cannot be part of equilibrium behaviour. The same argument shows that both sellers must offer the rebate $r^* = s$. Obviously, given $p^*$ this is the highest rebate a seller is willing to offer. If seller $i$ sets $r_i < s$, then seller $j$ would optimally charge his local customers some price $p_j > s$, which was already shown to be inconsistent with equilibrium.

The example demonstrates that price discrimination increases competition. The consumers have to pay lower prices and the firms' profits are reduced. Indeed, each seller earns a profit of $s$, which is lower than the profit he gets in the absence of discriminatory pricing. In the following, we will verify this observation in a more general model. In fact, the above example has some unappealing features because the consumers' purchasing decisions have to be based on a tie-breaking rule. Even though the equilibrium requires both sellers to use coupons, this marketing instrument is actually ineffective since no consumer is induced to switch. If the sellers had to pay a mailing cost, the above equilibrium would therefore collapse. The subsequent model will overcome these difficulties by introducing some consumer heterogeneity.

# 3 The Model

Following Shilony (1977), we study a market where consumers can purchase costlessly from a neighbourhood store, but incur some visiting cost if they venture a more distant store. There are two firms located in different regions, $A$ and $B$, that produce a homogeneous good at zero cost. Each region is inhabited by a unit mass of consumers who have a common reservation utility $v$ for the good. Each consumer can costlessly visit the store at his home location, while he has to pay a transportation cost $s$ to go to the other seller. It is assumed that $s$ is uniformly distributed on $[0, \bar{s}]$ across the population of consumers in each region. This assumption differs from Shilony's (1977) model of mixed pricing in oligopoly, where all consumers have the same visiting cost. It generates continuous demand functions, which are a prerequisite for the existence of a pure price setting equilibrium (see Bester (1992)).

The firms offer the good at the price $p_A$ and $p_B$, respectively. Without loss of generality, let $0 \leq p_i \leq v, i = A, B$. The seller cannot distinguish buyers from different regions once they enter the store. Similarly, he is uniformed about the visiting cost of the individual buyer. This means, he cannot make his price offer contingent on such information. But, seller $i$ may promote purchases by offering the consumers at location $j \neq i$ a rebate $r_i$, with $0 \leq r_i \leq p_i$. The seller may offer such rebates by mailing coupons to the other region. When firm $i$ sends coupons to a fraction $\lambda_i \in [0,1]$ of the consumers at location $j$, it has to pay the mailing cost $k(\lambda_i)$. Each consumer is equally likely to receive the rebate. This means, with probability $\lambda_i$ a consumer in region $j$ has to pay only $p_i - r_i$ for the good available at location $i$. The buyer who has not received a coupon is not entitled to a rebate and has to pay $p_i$. We assume that consumers do not interact with each other so that trading coupons is not possible.

The marketing strategy of firm $i$ may be described by $x_i = (p_i, r_i, \lambda_i)$. The cost function $k(.)$ is assumed to satisfy the following restrictions:

$$k(0) = 0,\ k'(\lambda) > 0,\ k''(\lambda) > 0,\ k'(0) < \bar{s}/4,\ k'(1) > \bar{s}/9. \tag{2}$$

The marginal cost of couponing is increasing in the number of households reached. This assumption is standard in the advertising literature (see Butters (1977) and Grossman and Shapiro (1984)). The underlying idea is that the manufacturer can distribute coupons via mail and by placing ads in a set of magazines or newspapers. The probability that a given consumer receives a coupon through one of these media is independent of receiving a coupon through the other media. In this case, the cost of making sure that a fraction $\lambda$ of consumers receives at least one coupon becomes a convex function of $\lambda$. The additional assumptions on $k'(.)$ guarantee that each manufacturer will choose some advertising intensity $0 < \lambda_i < 1$. In addition, we restrict the analysis to the case $v > \bar{s}$. This ensures that competition is sufficiently strong so that setting $p_i = v$ cannot be optimal for seller $i$.

# 4 Equilibrium

We assume that each consumer is aware of the availability of the good in both regions. In addition he knows the price charged by each of the sellers. In this situation, advertising conveys no information about the existence or the price of a good. Distributing coupons only serves to price discriminate between buyers from different regions. By offering a rebate the seller increases the attractiveness of his product for those consumers who have to spend the cost $s$ in order to visit his store.

To compute each seller's demand, one has to distinguish four groups of consumers: In each of the two regions the purchasing decision of the consumers who have received a coupon differs from those without a coupon. A consumer at location $A$ who has not received a coupon from firm $B$ purchases the good at his home location as long as $p_A \leq p_B + s$. If, however, he gets a coupon of value $r_B$, he will buy from seller $A$ only if $p_A \leq p_B - r_B + s$. When consumer $s$ at location $B$ is not offered a rebate, he will be attracted by firm $A$'s price offer if $p_A + s \leq p_B$. Otherwise, with a coupon $r_A$, he will purchase from firm $A$ if $p_A - r_A + s \leq p_B$.

Given the consumers' demand decisions, firm $A$'s profit $\Pi_A(x_A, x_B)$ depends on both firms' sales strategies and is given by

$$\Pi_A(x_A, x_B) = p_A(1-\lambda_B)D(\bar{s} - p_A + p_B) + p_A\lambda_B D(\bar{s} - p_A + p_B - r_B) \qquad (3)$$

$$+p_A(1-\lambda_A)D(p_B - p_A) + (p_A - r_A)\lambda_A D(p_B - p_A + r_A) - k(\lambda_A),$$

where

$$D(z) \equiv z/\bar{s} \text{ for } 0 \leq z \leq \bar{s}, \quad D(z) \equiv 0 \text{ for } z \leq 0, \quad \text{and } D(z) = 1, \text{ for } z \geq \bar{s}. \qquad (4)$$

By symmetry, firm $B$'s profit equals $\Pi_B(x_A, x_B) = \Pi_A(x_B, x_A)$. To study equilibrium advertising in this market, we consider the Nash equilibrium in the sellers' game. Thus a pair $(x_A^*, x_B^*)$ of marketing strategies constitutes an equilibrium if $\Pi_A(x_A^*, x_B^*) \geq \Pi_A(x_A, x_B^*)$ for all $x_A$, and $\Pi_B(x_A^*, x_B^*) \geq \Pi_B(x_A^*, x_B)$ for all $x_B$.

Our first result provides a characterization of the symmetric pure strategy equilibrium.

**Proposition 1:** *Let $(x_A^*, x_B^*)$ be an equilibrium such that $x_A^* = x_B^* = (p^*, r^*, \lambda^*)$. Then $(p^*, r^*, \lambda^*)$ is given by the unique solution to*

$$p^* = \bar{s}/(1+0.5\lambda^*), \quad r^* = 0.5p^*, \quad k'(\lambda^*) = p^*/(4+2\lambda^*).$$

Figure 1 illustrates that the equilibrium is indeed unique: The $P-P$ schedule depicts all $p-\lambda$ combinations such that $p = \bar{s}/(1+0.5\lambda)$; the $K-K$ schedule describes the function $p = k'(\lambda)(4+2\lambda)$. Assumption (1) ensures that the two functions intersect at some point $(p^*, \lambda^*)$ within the area $(0, \bar{s}) \times (0, 1)$. This intersection determines the equilibrium values $p^*$ and $\lambda^*$.

With the help of Figure 1 we can easily establish some comparative statics properties of the equilibrium outcome $(p^*, r^*, \lambda^*)$. For instance, an increase in the marginal cost $k'(.)$ leads to a higher equilibrium price $p^*$ and a lower level of advertising $\lambda^*$ because the $K-K$ schedule is shifted upwards. How does the equilibrium react to a change in the consumers' transportation cost? Increasing the parameter $\bar{s}$ is equivalent to increasing

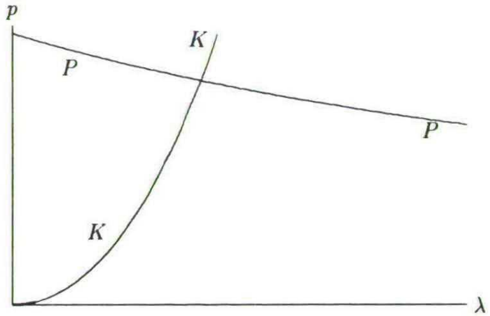


**Figure 1:** Equilibrium $(p^*, \lambda^*)$

each consumer's switching cost by the same factor. In Figure 1 this leads to an upward shift of the $P - P$ schedule. Consequently, both $p^*$ and $\lambda^*$ are increased.

Not all consumers who are couponed will make use of the rebate. Redeeming the coupon is worthwhile only when $s \leq r^* = p^* - r^*$. Accordingly, the redemption rate is $(p^* - r^*)/\bar{s} = 1/(2 + \lambda^*)$. That is, more than one half of the coupons is not returned to the manufacturer. Using the above comparative statics results, it follows that the equilibrium redemption rate is increasing in the marginal cost of couponing. A cost increase reduces the number of households that are couponed, but the fraction of households that redeem the coupon is increased. An increase in the consumers' transportation cost has the opposite effect: More households are couponed, but a lower fraction returns the coupon. Note, however, that the total number of coupons actually redeemed is given by $\lambda^*/(2+\lambda^*)$, which is increasing in $\lambda^*$. This number is, therefore, negatively related to the marginal cost of couponing and positively related to the level of consumer switching costs.

Of course, the result that the coupon offers a 50% price rebate is specific to the setting of our model. In particular, the uniform distribution of switching costs is important in this context. One can show that the sellers would optimally offer a lower rebate if the distribution of $s$ puts more weight on low switching costs. The intuition is that attracting high cost consumers through a rebate is not profitable when these consumers represent only a small fraction of the total population.

Proposition 1 only provides an implicit characterization of the equilibrium values $p^*, r^*$, and $\lambda^*$. To obtain an explicit solution of the equilibrium, one has to look at a parametric example of the cost function $k(.)$. The simplest example is $k(\lambda) = c\lambda^3$. This function satisfies restriction (2) if $c > \bar{s}/27$. The equilibrium described by Proposition 1 is then given by

$$p^* = 2[3c\bar{s} + \bar{s}(3c\bar{s})^{1/2}]^{1/2} - 2(3c\bar{s})^{1/2}, \quad \lambda^* = [1 + \bar{s}(3c\bar{s})^{-1/2}]^{1/2} - 1. \tag{5}$$

The equilibrium characterization by Proposition 1 is derived from the first order conditions that the profit maximizing marketing strategies $x_A$ and $x_B$ necessarily have to satisfy. Unfortunately, the first order conditions are not sufficient for profit maximization. The reason is that the firms' profit functions are not jointly concave in $(p_i, r_i, \lambda_i)$. Because of this non-concavity, one has to be careful that no seller can increase his profit by, for instance, simultaneously lowering his price and his advertising intensity. The following assumption guarantees that such deviations from $(p^*, r^*, \lambda^*)$ are not profitable.

**Assumption 1:** For all $0 \leq \lambda_1 < \lambda_2 \leq 1$, $k(.)$ satisfies $k'(\lambda_2)/k'(\lambda_1) > (1 + \lambda_2 - \lambda_1)^2$.

This assumption requires the cost function $k(.)$ to be sufficiently convex, which allows us to establish existence of a pure strategy equilibrium.

**Proposition 2:** *Let $k(.)$ satisfy Assumption 1. Then, there is an equilibrium $(x_A^*, x_B^*)$ such that $x_A^* = x_B^* = (p^*, r^*, \lambda^*)$.*

Within the family of cost functions $k(\lambda) = c\lambda^\alpha$, Assumption 1 is satisfied as long as $\alpha \geq 3$. Therefore, the above example satisfies this assumption and the solution described by equation (5) constitutes an equilibrium outcome. Assumption 1 guarantees that the seller's optimal advertising intensity is not very sensitive to price changes. In general, the optimal distribution rate $\lambda_i$ is positively related to seller $i$'s price $p_i$. Under Assumption 1, however, a given reduction in $p_i$ has only a small impact on the optimal $\lambda_i$. This ensures that seller $i$ cannot gain from setting $p_i < p^*$ together with $\lambda_i < \lambda^*$.

Even though the manufacturer's profit function is not jointly concave in $(p_i, r_i, \lambda_i)$, it is continuous. This implies that there is a mixed strategy Nash equilibrium when Assumption 1 is not satisfied (see Dasgupta and Maskin (1986)). In such an equilibrium the sellers choose a random marketing policy. Since for a given $\lambda_i$, seller $i$'s profit is concave in $(p_i, r_i)$, it follows from the first order conditions that the optimal $p_i$ is positively related with $\lambda_i$. Similarly, the optimal $r_i$ increases with $p_i$. In the mixed strategy equilibrium, therefore, each seller chooses $\lambda_i$ stochastically and he combines higher values of $\lambda_i$ with higher prices $p_i$ and higher coupon values $r_i$.

# 5 Welfare

In this section we investigate how the market participants' welfare depends on the advertising cost $k(.)$ and the transportation cost parameter $\bar{s}$. As a measure of consumer welfare, we consider aggregate consumer surplus, $C$, which depends on $(p^*, r^*, \lambda^*)$ according to

$$C(p^*, r^*, \lambda^*) = 2(1-\lambda^*)(v-p^*) + 2\lambda^* \int_{[0,\bar{s}]} \max[v-p^*, v-p^*+r^*-s]/\bar{s}\, \mathrm{d}s. \qquad (6)$$

The first term represents the utility of the consumers who do not receive a coupon. The other consumers' purchasing decision depends on the rebate $r^*$ and the switching cost $s$. Consumer $s$ will make use of the coupon only if $v-p^* \geq v-p^*+r^*-s$. Finally, we define social welfare as the sum of producer profits and consumer surplus. We begin by studying the relation between welfare and $\bar{s}$.

**Proposition 3:** *The sellers' equilibrium profit is increasing in $\bar{s}$. Consumer surplus and social welfare are decreasing in $\bar{s}$.*

Not surprisingly, producer profits are positively related to the level of brand loyalty or geographical differentiation. When the sellers are able to choose products, they will seek to maximize the degree of market segmentation. The principle of 'maximal differentiation', as described by D'Aspremont et al. (1979), remains valid when couponing is introduced. An increase in $\bar{s}$ has a two-fold impact on consumer surplus: First, the consumer has to pay higher prices. Second, he is more likely to receive a coupon. The above result demonstrates that the first negative effect outweighs the second positive effect. Indeed, as was shown before, the coupon redemption rate decreases with $\bar{s}$. Finally, social welfare is negatively related to $\bar{s}$ : The higher $\bar{s}$, the higher is the coupon distribution intensity, $\lambda^*$, and the number of coupons actually redeemed, $\lambda^*/(2+\lambda^*)$. This means that the resources spend on couponing and the consumers' aggregate travel costs increase with $\bar{s}$.

To study the impact of the advertising cost on equilibrium payoffs, we consider cost functions of the type $k(\lambda) = c\lambda^\alpha$. An increase in the parameter $c$ then shifts the cost function upwards so that also the marginal cost of advertising is increased.

**Proposition 4:** *Let $k(\lambda) = c\lambda^\alpha$, with $\alpha \geq 3$. Then equilibrium profits and social surplus are increasing in $c$. Consumer surplus is decreasing in $c$.*

Surprisingly, an increase in the cost of couponing makes the sellers better off. Of course, seller $i$ gains by a reduction in $c$ when the marketing strategy $x_j$ of his opponent is kept fixed. In addition to this direct effect, however, there is an indirect effect. Lower advertising costs make competition more aggressive. This reduces the sellers' prices and their equilibrium profits. A similar observation has been made in models of informative advertising (see Bester and Petrakis (1992), and Peters (1984)), where a tax on advertising may increase profits. Since higher couponing costs increase prices and reduce coupon distribution, the consumers become worse off. Aggregate welfare, however, is increased. The intuition is that the sellers waste less resources on couponing consumers and the consumers save on switching costs.

# 6 Conclusions

This paper has studied couponing as a price discrimination device in oligopolistic competition. By couponing those consumers who have some preference for a competing brand, a seller can increase his market share. Coupons may compensate the consumer for a costly movement to another brand. In contrast with the repeat-purchase explanation, coupons reduce consumer switching costs in our model. The price discrimination model predicts that couponing intensifies competition between the sellers, leading to lower prices and profits.

Our simple model may be extended in several interesting directions. We assumed that all the consumers have the same valuation for the good. As a result, total demand was fixed. Introducing some dispersion of consumer valuations would make aggregate demand elastic. As couponing increases competition, it would raise aggregate output. Couponing may have a positive effect on social welfare if the elasticity of demand is sufficiently high. Also, the value of the coupon relative to the price of the product would presumably depend on the distribution of consumer valuations.

Removing the symmetric structure of the model would be another interesting extension. In our model, the sellers were identical and so they used the same marketing strategy. This would no longer be the case when different production technologies are considered. An extension along these lines could provide insights into the relation between a firm's efficiency and its marketing policy. Similarly, one could study the role of a firm's size when the number of consumers differs across market segments. One might expect that smaller firms have a higher incentive to distribute coupons because they can gain more by attracting consumers from other market segments.

# 7 Appendix

**Lemma 1:** *Let $x_i$ be an optimal marketing strategy for firm i given that firm j chooses $x_j$. Then the following must hold: (i) $p_j - \bar{s} \leq p_i - r_i < p_j$; (ii) $p_j - \bar{s} \leq p_i < p_j + \bar{s}$; and (iii) $p_i \geq \min[p_j - r_j, 0.5p_j]$.*

**Proof:** If $p_i - r_i \geq p_j$, no consumer will switch from location $j$ to firm $i$. Therefore, firm $i$ could increase its profit by not mailing coupons. If $p_i - r_i < p_j - \bar{s}$, all consumers at location $j$ who receive a coupon from firm $i$ strictly prefer to switch. Therefore, firm $i$ could increase its profits by slightly decreasing $r_i$. This proves (i). To prove (ii), note that all consumers at $j$ strictly prefer to switch to firm $i$ if $p_i < p_j - \bar{s}$. Therefore, firm $i$ could increase its profit by slightly increasing $p_i$. If $p_i \geq p_j + \bar{s}$, no consumer at location $i$ buys from firm $i$. But then firm $i$ could get higher profits by setting $p_i$ slightly below $p_j + \bar{s}$, while keeping $p_i - r_i$ constant. Finally, (iii) must hold because keeping $p_i - r_i$ fixed and increasing $p_i$ increases $\Pi_i$ if $p_i < \min[p_j - r_j, 0.5p_j]$. Q.E.D.

**Lemma 2:** *Let $x_i$ be an optimal marketing strategy for firm i given that firm j chooses $x_j$. Then $p_i - r_i = 0.5p_j$.*

**Proof:** By the definition of $\Pi_i(.)$, $p_i - r_i$ must maximize $(p_i - r_i)D[p_j - (p_i - r_i)]$. By lemma 1, the solution must satisfy the first order condition $p_j - 2(p_i - r_i) = 0$. Q.E.D.

**Proof of Proposition 1:** Lemma 2 implies $r^* = 0.5p^*$. This together with the first order condition for the optimal choice of $\lambda_i$ implies $k'(\lambda^*) = [p^*/2]^2/\bar{s}$. We show firm $A$ cannot gain by setting $p_A > p^*$ only if $p^* \geq \bar{s}/(1 + 0.5\lambda^*)$. By lemma 2, firm $A$ will optimally set $p_A - r_A = 0.5p^*$. Therefore, the profit from choosing $p_A \in (p^*, p^* + \bar{s})$ together with $\lambda_A = \lambda^*$ equals

$$\Pi_A = [p_A(1 - \lambda^*)(\bar{s} - p_A + p^*) + p_A\lambda^*(\bar{s} - p_A + 0.5p^*) + \lambda^*(p^*/2)^2]/\bar{s} - k(\lambda^*). \tag{7}$$

This implies $\partial\Pi_A/\partial p_A = [\bar{s} - 2p_A + p^*(1 - 0.5\lambda^*)]/\bar{s}$. If $p^* < \bar{s}/(1 + 0.5\lambda^*)$, then for $p_A$ close enough to $p^*$ one gets $\partial\Pi_A/\partial p_A > 0$ so that firm $A$ could gain by charging a price slightly above $p^*$. As a result, one must have $p^* \geq \bar{s}/(1 + 0.5\lambda^*)$.

Finally, we show that firm $A$ cannot gain by setting $p_A < p^*$ only if $p^* \leq \bar{s}/(1+0.5\lambda^*)$. The profit from choosing $p_A \in (p^* - r^*, p^*)$ together with $\lambda_A = \lambda^*$ and $p_A - r_A = 0.5p^*$ equals

$$\Pi_A = p_A(1-\lambda^*) + [p_A\lambda^*(\bar{s} - p_A + 0.5p^*) + p_A(1-\lambda^*)(p^* - p_A)]/\bar{s} \tag{8}$$

$$+\lambda^*(p^*/2)^2/\bar{s} - k(\lambda^*).$$

Therefore, $\partial\Pi_A/\partial p_A = [\bar{s} - 2p_A + p^*(1-0.5\lambda^*)]/\bar{s}$. If $p^* > \bar{s}/(1+0.5\lambda^*)$, then for $p_A$ close enough to $p^*$ one gets $\partial\Pi_A/\partial p_A < 0$ so that firm $A$ could gain by charging a price slightly below $p^*$. As a result, one must have $p^* \leq \bar{s}/(1+0.5\lambda^*)$. Q.E.D.

**Proof of Proposition 2:** Let firm $B$ use the strategy $x_B^* = (p^*, r^*, \lambda^*)$ such that $p^*, r^*$, and $\lambda^*$ satisfy the conditions of Proposition 1. We will show that adopting the same strategy is a best response for firm $A$.

First we show that choosing some $p_A > p^*$ is not profitable for firm $A$. By lemma 2, firm $A$ will optimally set $p_A - r_A = 0.5p^*$. Therefore, the profit from choosing $p_A \in (p^*, p^* + \bar{s})$ together with some $\lambda_A$ equals

$$\Pi_A = [p_A(1-\lambda^*)(\bar{s} - p_A + p^*) + p_A\lambda^*(\bar{s} - p_A + 0.5p^*) + \lambda_A[p^*/2]^2]/\bar{s} - k(\lambda_A). \tag{9}$$

From the first order condition it follows that firm $A$ will optimally set $\lambda_A = \lambda^*$. This implies

$$\partial\Pi_A/\partial p_A = [(1-\lambda^*)(\bar{s} - 2p_A + p^*) + \lambda^*(\bar{s} - 2p_A + 0.5p^*)]/\bar{s} < 0, \tag{10}$$

where the inequality follows from $p_A > p^* = \bar{s}/(1+0.5\lambda^*)$ Thus, firm $A$ cannot gain by adopting some strategy $x_A \neq (p^*, r^*, \lambda^*)$ such that $p_A > p^*$.

To complete the argument, we show that choosing some $p_A < p^*$ is not profitable for firm $A$. As firm $A$ will optimally set $p_A - r_A = 0.5p^*$, its profit from choosing $p_A \in (p^* - r^*, p^*)$ together with some $\lambda_A$ equals

$$\Pi_A = p_A(1-\lambda^*) + [p_A\lambda^*(\bar{s} - p_A + 0.5p^*) + p_A(1-\lambda_A)(p^* - p_A)]/\bar{s} \tag{11}$$

$$+\lambda_A[p^*/2]^2/\bar{s} - k(\lambda_A).$$

For any $p_A < p^*$ the optimal choice of $\lambda_A$ has to satisfy the first order condition $p_A(p^* - p_A) = \bar{s}[k'(\lambda^*) - k'(\lambda_A)]$, so that $\lambda_A < \lambda^*$ by convexity of $k(.)$ This equation can be rewritten as

$$p_A^2 - p_A p^* + \bar{s}[k'(\lambda^*) - k'(\lambda_A)] = 0. \tag{12}$$

Note that $p^{*2} - 4\bar{s}[k'(\lambda^*) - k'(\lambda_A)] = 4\bar{s}k'(\lambda_A)$ and that, by lemma 1, $p_A \geq 0.5p^*$. Therefore, the above equation yields the solution

$$p_A = 0.5p^* + [\bar{s}k'(\lambda_A)]^{1/2}. \tag{13}$$

As $2p_A - p^* = 2[\bar{s}k'(\lambda_A)]^{1/2}$ and $\bar{s} - 0.5\lambda^* p^* = p^* = 2[\bar{s}k'(\lambda^*)]^{1/2}$, differentiation of $\Pi_A$ yields

$$\begin{aligned} \partial\Pi_A/\partial p_A &= [\bar{s} - 0.5\lambda^* p^* - (1 + \lambda^* - \lambda_A)(2p_A - p^*)]/\bar{s} \\ &= [2[\bar{s}k'(\lambda^*)]^{1/2} - 2(1 + \lambda^* - \lambda_A)[\bar{s}k'(\lambda_A)]^{1/2}]/\bar{s}. \end{aligned} \tag{14}$$

Since $\lambda_A < \lambda^*$, Assumption 1 implies $\partial\Pi_A/\partial p_A > 0$. Thus firm A cannot gain by adopting some strategy $x_A \neq (p^*, r^*, \lambda^*)$ such that $p_A < p^*$. Q.E.D.

**Proof of Proposition 3:** Equilibrium profits are given by

$$\begin{aligned} \Pi_i &= p^* - \lambda^* p^{*2}/4\bar{s} - k(\lambda^*) = 4k'(\lambda^*)(1 + 0.5\lambda^*) - \lambda^* k'(\lambda^*) - k(\lambda^*) \\ &= 4k'(\lambda^*) + \lambda^* k'(\lambda^*) - k(\lambda^*). \end{aligned} \tag{15}$$

By convexity of $k(.)$, $\Pi_i$ is increasing in $\lambda^*$. As a result, $\bar{s}$ and $\Pi_i$ are positively related because $\lambda^*$ is an increasing function of $\bar{s}$.

Consumer surplus equals

$$\begin{aligned} C &= 2v - 2p^* + \lambda^* p^{*2}/4\bar{s} = 2v - 8k'(\lambda^*)(1 + 0.5\lambda^*) + \lambda^* k'(\lambda^*) \\ &= 2v - 8k'(\lambda^*) - 3\lambda^* k'(\lambda^*) \end{aligned} \tag{16}$$

As an increase in $\bar{s}$ raises $\lambda^*$, this proves that consumer surplus is decreasing in $\bar{s}$.

Social welfare equals $W = 2\Pi_i + C = 2v - 2k(\lambda^*) - \lambda^* k'(\lambda^*)$. An increase in $\bar{s}$ leads to a higher value of $\lambda^*$ so that the social welfare is reduced. Q.E.D.

**Proof of Proposition 4:** For $k(\lambda) = c\lambda^{\alpha}$ one has $\lambda k'(\lambda)/\alpha = k(\lambda)$. Therefore

$$\Pi_i = p^* - \lambda^* p^{*2}/4\bar{s} - \lambda^* k'(\lambda^*)/\alpha = p^*[1 - (1+\alpha)\lambda^* p^*/(4\bar{s}\alpha)]. \tag{17}$$

But $\lambda^* p^* = 2(\bar{s} - p^*)$. Since an increase in $k'(\lambda)$ raises $p^*$, $\lambda^* p^*$ falls when $c$ is increased. This proves that $\Pi_i$ and $c$ are positively related.

By the proof of Proposition 3, social welfare equals

$$\begin{aligned} W &= 2v - 2\lambda^* k'(\lambda^*)/\alpha - \lambda^* k'(\lambda^*) = 2v - (\alpha+2)\lambda^* p^{*2}/(4\alpha\bar{s}) \\ &= 2v - (\alpha+2)(\bar{s} - p^*)p^*/(2\alpha\bar{s}). \end{aligned} \tag{18}$$

Since $2\bar{s}/3 \leq p^* \leq \bar{s}$, $W$ is increasing in $p^*$. Therefore, an increase in $c$ will raise $W$. Finally, as an increase in $c$ raises $p^*$ and lowers $\lambda^*$, each consumer's equilibrium utility will decrease with $c$. Accordingly, consumer surplus is a decreasing function of $c$. Q.E.D.

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