

A model of targeted advertising based on consumer purchase history

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Abstract: This paper develops a two-period sales model to investigate the competitive effects of targeted advertising based on consumer purchase history. In our model, two competing firms gain consumer information during the first period sales, which enables them to target advertising toward their old customers in the second period. Advertising is assumed to be persuasive in terms of consumer valuation increasing and product substitutability decreasing. We find that, the firm's ability of targeting may damage industry profits, consumer surplus and even social welfare. The conditions under which targeted advertising is positive or negative are derived, showing that competition is softened in the second period but intensified in the first period because of the anticipation behavior of the competing firms. It is suggested that firms in competing environments cautiously initiate targeted advertising with appropriate contents.

Keywords: Targeted Advertising, Persuasive Advertising, Consumer Purchase History, Behavior-Based Price Discrimination

1. Introduction

The development of the Internet as a one-to-one medium and the increasing use of sophisticated information-related skills to gather, store and analyze consumer information have unimaginably helped firms to segment a heterogeneous market through consumers' past behavior, and to initiate individual marketing approaches accordingly in subsequent periods. "Behavior-based marketing" is practiced as various forms, including price conditioning, product customization, service personalization, and advertising targeting. This paper focuses on the targeting of advertising and prices based on consumer purchase history, which has been widely adopted, for example, by Amazon,

eBay, YouTube, Double-click, Google, to name a few.

We establish a two-period duopoly model with forward-looking firms and myopic consumers. In the first period, the two firms compete for and divide the market with uniform prices. In the subsequent period, with information about consumers' purchase histories revealed during the initial period, each firm is able to target advertising toward their old customers and to price discriminate between new customers and old ones. Advertising is persuasive in the way that enhances consumer valuation and reduces product substitutability.

We find that in a duopoly market the firm's ability of targeting does not necessarily benefit profits. It softens the second period competition on the one hand, but aggravates the first period competition on the other hand. The positive effect is owing to the role of targeted advertising and the negative effect results from the anticipation behaviors of the competing firms. The negative effect may dominate the positive one, hence damaging each firm's profit. We also discuss the implications of consumer surplus and social welfare, showing that depending on whether the enhanced consumer valuation outweighs the reduced product substitutability, consumer surplus and social welfare may be hurt or improved. Furthermore, we find the possibility that targeted advertising may enhance both industry profits and consumer surplus, thereby achieving a Pareto improvement throughout the entire market.

This paper contributes to two strands of the literature, namely, targeted advertising and behavior-based price discrimination (henceforth BBPD). We first give an overview on the economics of targeted advertising. Previous works generally stress the anti-competitive effect that targeted advertising plays, assuming that firms have perfect consumer preference information *ex ante*. For instance, focusing on the informative role of advertising, Iyer et al. (2005) find that targeted advertising mitigates competition between firms; when advertising is persuasive, Shaffer and Zettelmeyer (2004) and Wu et al. (2009) demonstrate the possibility that targeted advertising may partially or even completely mitigate the conflict between the upstream and downstream firms in a distribution channel. The assumption that consumer preference is common knowledge *ex ante* and the result that targeted advertising alleviates competition are also found in Hernández-García (1997) and Esteban et al. (2001) who focus on the monopoly framework, and in Roy (2000) and Galeotti and Moraga-González (2008) who consider a duopoly model.

Our present work contributes this stream of literature by proposing a two-period duopoly model where firms learn consumer preference in the first period based on which advertising targeting is practicable in the subsequent period,

showing that targeted advertising may mitigate or aggravate competition between firms under different circumstances.

The other relevant area of research is the issue of BBPD. Based on consumer purchase history, firms can price discriminate among heterogeneous consumers? Generally speaking, in a competitive market, BBPD has important precompetitive effects and the firm's ability to price discriminate is always bad for profits and not necessarily good for consumer surplus or social welfare (Shaffer and Zhang, 1995; Chen et al., 1997; Villas-Boas, 1999; Fudenberg and Tirole, 2000; Esteves, 2010; Zhang, 2011). However, under special circumstances, it is still possible for firms to benefit from BBPD. Shaffer and Zhang (2000) find that when consumers have heterogeneous brand loyalty in a duopoly market, it is possible that one firm or even both firms earn higher profits than they would earn if BBPD were impracticable. This conclusion still holds if the firms differ in size and demand (Shaffer and Zhang, 2002). When firms are able to offer enhanced service to previous customers, Acquit and Varian (2005) show that it is profitable for firms to condition prices on consumer purchase history. In case of horizontal mergers among three firms, Esteves and Vasconcelos (2010) show that BBPD boosts industry profits at the expense of consumer surplus, leaving social welfare unaffected. Perhaps the most related works to ours are Chen and Zhang (2009) and Esteves (2009) who propose two-period duopoly models where BBPD is not feasible *ex ante*. The period-1 losing firm learns each consumer's identification and thus BBPD is only practicable by this firm. In this way, BBPD has anti-competitive effects and it is always good for profits. Our model differs from theirs in that the market is shared by the two competing firms in the first period; hence each firm in the second period is able to target prices according to consumer types.

Our present work contributes this stream of literature by demonstrating that BBPD combined with targeted advertising mitigates the second period competition but aggravates the first period competition when competing firms anticipate their future profits. Industry profits, consumer surplus, and social welfare may be damaged or improved, depending on the persuasive role of advertising.

2. Model

2.1 Supply Side

Consider a standard Hotelling market with two firms located at the two ends of a unit line $[0, 1]$. Denote the firm located at point 0 as firm A and the firm at point 1 as firm B . Firm i sells product i to end consumers with a constant marginal production cost, which is normalized to zero without loss of generality (throughout this paper, $i, j = A, B, i \neq j$).

2.2 Demand Side

Consumers are uniformly distributed along the market with a density of one. Upon purchasing product A or B , consumers obtain a common valuation $V > 0$. For competition to have relevance, V is assumed to be sufficiently large to ensure full market coverage (Tirole, 1988). Therefore, a consumer located at $x \in [0, 1]$ obtains a gross utility $V - tx$ and $V - t(1 - x)$ from the consumption of product A and B , respectively, where $t > 0$ is the transportation cost per unit of length.

2.3 The Role of Advertising

According to Tirole (1988) and Bagwell (2007), two main views have emerged in the literature on the role of advertising. Informative advertising is generally used to announce the existence of a product and thus reduce consumers' search costs; whereas persuasive advertising can alter consumer tastes to create high product differentiation and inelastic demand. We assume advertising is persuasive and it alters consumers' tastes and creates high product differentiation. To reflect the taste altering effect, we assume that being exposed to firm i 's ads, consumers' valuation for product i increases from V to $V + \Delta V$, where $\Delta V > 0$. To reflect the product differentiation creating effect, we further assume that consumers' transportation parameter increases from t to $t + \Delta t$, where $\Delta t > 0$, considering that t is an effect measure of product differentiation and that an increase in t implies that consumers are less price sensitive and product differentiation (Substitutability) is higher (lower). The assumptions above directly follow Shaffer and Zettelmeyer (2004) and Wu et al. (2009) who assume that advertising increase consumers' valuation and at the same time reduces the product substitution through increasing the transportation cost. We caution that the values of ΔV and Δt depend on the contents that a piece of advertising message displays. If the message is designed to emphasize its own product's high value, ΔV will be large. In contrast, if the message is likely to

illustrate the dissimilarities between its product and other brands, Δt will be large.

2.4 Two-Period Game

To model the characteristics of targeted advertising based on consumer purchase history, we introduce a two-period game played between the firms. Each consumer desires at most one product in each period.

In period 1, both firms cannot persuade consumers by advertising for the lack of consumer information. The two firms simultaneously set a uniform price p_1 , and then consumers purchase the product which brings them the highest positive surplus. After the first period sales, firms are able to tell their old customers from the market with the help of consumer purchase history, based on which targeted advertising and prices can be initiated.

In period 2, firm i may target persuasive advertising toward its old customers whose valuation and transportation parameter for product i thus increases to, respectively, $V + \Delta V$ and $t + \Delta t$. Our assumption implies that new customers are not exposed to advertising because, for example, firms cannot obtain their e-mail addresses or phone numbers without any deal. To ensure the existence of sub game perfect Nash equilibrium in pricing strategies, we assume that $\Delta V < t + \Delta t$. After advertising decisions being made, firms simultaneously set personalized prices p_{i2}^o and p_{i2}^n , where the superscripts "o" and "n" refer to, respectively, old customers and new ones. To isolate the effects of targeted advertising, we assume that consumers are myopic in the way that they do not anticipate their further surplus. Firms are strategic and forward-looking in the way that they discount future profits with a common discount rate $\delta \in [0, 1]$.

3. Main Analysis

We derive the equilibrium results of the two-period game using backward induction method, based on which profit and welfare implications are proposed.

3.1 The Second Period

Under the assumption of full market coverage, in the first period there must exist a marginal consumer, denoted by \hat{x} , who is indifferent between the two brands. Then in the second period, firm A 's old customers come from the segment $[0, \hat{x})$, and firm B 's from the segment $(\hat{x}, 1]$. Due to discriminatory prices, competition in the second period over either segment is a duopoly pricing game.

First consider the segment $[0, \hat{x}]$, which consists of firm A's (B's) old (new) customers. Firm A has a choice to target advertising to this segment or not. If firm A chooses to sponsor ads, the indifferent consumer, denoted by \bar{x} , is then determined by $V + \Delta V - p_{A2}^o - \bar{x}(t + \Delta t) = V - p_{B2}^n - (1 - \bar{x})(t + \Delta t)$, i.e.,

$$\bar{x} = \frac{t + \Delta t + \Delta V - p_{A2}^o + p_{B2}^n}{2(t + \Delta t)}. \tag{1}$$

Then, firm A's period 2 profit obtained from the old customers is $\pi_{A2}^o = p_{A2}^o \bar{x}$ whose first order condition is

$$\frac{\partial \pi_{A2}^o}{\partial p_{A2}^o} = \frac{t + \Delta t + \Delta V - 2p_{A2}^o + p_{B2}^n}{2(t + \Delta t)} = 0,$$

and firm B's period 2 profit obtained from the new customers is $\pi_{B2}^n = p_{B2}^n (\hat{x} - \bar{x})$, with the first order condition

$$\frac{\partial \pi_{B2}^n}{\partial p_{B2}^n} = \hat{x} - \frac{t + \Delta t + \Delta V - p_{A2}^o + 2p_{B2}^n}{2(t + \Delta t)} = 0.$$

Clearly, the second order conditions are satisfied. Solving $\frac{\partial \pi_{A2}^o}{\partial p_{A2}^o} = 0$ and $\frac{\partial \pi_{B2}^n}{\partial p_{B2}^n} = 0$ simultaneously yields period 2 prices the segment $[0, \hat{x}]$ faces

$$\begin{aligned} p_{A2}^o &= \frac{2\hat{x} + 1}{3}(t + \Delta t) + \frac{\Delta V}{3}, \\ p_{B2}^n &= \frac{4\hat{x} - 1}{3}(t + \Delta t) - \frac{\Delta V}{3}, \end{aligned} \tag{2}$$

putting which back into $\pi_{A2}^o = p_{A2}^o \bar{x}$ and $\pi_{B2}^n = p_{B2}^n (\hat{x} - \bar{x})$ yields period 2 profits earned from the segment $[0, \hat{x}]$:

$$\begin{aligned} \pi_{A2}^o &= \frac{[(2\hat{x} + 1)(t + \Delta t) + \Delta V]^2}{18(t + \Delta t)}, \\ \pi_{B2}^n &= \frac{[(4\hat{x} - 1)(t + \Delta t) - \Delta V]^2}{18(t + \Delta t)}. \end{aligned} \tag{3}$$

From the expression of π_{A2}^o , we clearly see that no advertising (i.e., $\Delta t = 0, \Delta V = 0$) is a dominated strategy for firm A. Therefore, firm A will choose to target advertising to this segment.

Then consider the segment $(\hat{x}, 1]$, which consists of firm B's (A's) old (new) customers. If firm B advertises to this segment, the indifferent consumer, denoted by \tilde{x} , is determined by

$$\begin{aligned} V - p_{A2}^n - \tilde{x}(t + \Delta t) &= V + \Delta V - p_{B2}^o - (1 - \tilde{x})(t + \Delta t), \text{ i.e.,} \\ \tilde{x} &= \frac{t + \Delta t - \Delta V - p_{A2}^n + p_{B2}^o}{2(t + \Delta t)}. \end{aligned} \tag{4}$$

Then, firm B 's period 2 profit obtained from the old customers is $\pi_{B2}^o = p_{B2}^o(1 - \tilde{x})$, whose first order condition is

$$\frac{\partial \pi_{B2}^o}{\partial p_{B2}^o} = 1 - \frac{t + \Delta t - \Delta V - p_{A2}^n + 2p_{B2}^o}{2(t + \Delta t)} = 0$$

and firm A 's period 2 profit obtained from the new customers is $\pi_{A2}^n = p_{A2}^n(\tilde{x} - \hat{x})$, with the first order condition

$$\frac{\partial \pi_{A2}^n}{\partial p_{A2}^n} = \tilde{x} - \frac{t + \Delta t - \Delta V - 2p_{A2}^n + p_{B2}^o}{2(t + \Delta t)} = 0.$$

Since the second order conditions are satisfied, solving $\frac{\partial \pi_{B2}^o}{\partial p_{B2}^o} = 0$ and $\frac{\partial \pi_{A2}^n}{\partial p_{A2}^n} = 0$ simultaneously yields period 2 prices the segment $(\hat{x}, 1]$ faces:

$$\begin{aligned} p_{B2}^o &= \frac{3 - 2\hat{x}}{3}(t + \Delta t) + \frac{\Delta V}{3}, \\ p_{A2}^n &= \frac{3 - 4\hat{x}}{3}(t + \Delta t) - \frac{\Delta V}{3}, \end{aligned} \tag{5}$$

putting which back into $\pi_{B2}^o = p_{B2}^o(1 - \tilde{x})$ and $\pi_{A2}^n = p_{A2}^n(\tilde{x} - \hat{x})$ yields period 2 profits earned from the segment $(\hat{x}, 1]$:

$$\begin{aligned} \pi_{B2}^o &= \frac{[(3 - 2\hat{x})(t + \Delta t) + \Delta V]^2}{18(t + \Delta t)}, \\ \pi_{A2}^n &= \frac{[(3 - 4\hat{x})(t + \Delta t) - \Delta V]^2}{18(t + \Delta t)}. \end{aligned} \tag{6}$$

Similarly, the expression of π_{B2}^o shows that no advertising is also a dominated strategy for firm B . Thus, in equilibrium firm B will choose to target advertising to its old customers.

From Eqs. (3) and (6) we obtain firm i 's period 2 profit as $\pi_{i2} = \pi_{i2}^o + \pi_{i2}^n$ i.e.,

$$\begin{aligned} \pi_{A2} &= \frac{[(2\hat{x} + 1)(t + \Delta t) + \Delta V]^2 + [(3 - 4\hat{x})(t + \Delta t) - \Delta V]^2}{18(t + \Delta t)}, \\ \pi_{B2} &= \frac{[(3 - 2\hat{x})(t + \Delta t) + \Delta V]^2 + [(4\hat{x} - 1)(t + \Delta t) - \Delta V]^2}{18(t + \Delta t)}. \end{aligned} \tag{7}$$

Note that if we substitute \hat{x} with $1 - \hat{x}$, then changes π_{i2} into π_{j2} . In other words, π_{A2} and π_{B2} are symmetric with respect to \hat{x} . This symmetry property is useful for us to derive the first period equilibrium.

3.2 The First Period

In the first period, the two firms quote uniform prices for the lack of consumer information. The indifferent consumer \hat{x} is then determined by $V - p_{A1} - \hat{x}t = V - p_{B1} - (1 - \hat{x})t$, i.e.,

$$\hat{x} = \frac{t - p_{A1} + p_{B1}}{2t}. \tag{8}$$

Firm A and firm B receive period 1 profits, respectively, $\pi_{A1} = p_{A1}\hat{x}$ and $\pi_{B1} = p_{B1}(1 - \hat{x})$, which can be expressed as

$$\pi_{i1} = p_{i1} \frac{t - p_{i1} + p_{j1}}{2t}. \tag{9}$$

Furthermore, due to symmetry, putting Eq.(8) into Eq.(7) we can express firm i 's period 2 profit as

$$\pi_{i2} = \frac{[(2\frac{t-p_{i1}+p_{j1}}{2t} + 1)(t + \Delta t) + \Delta V]^2 + [(3 - 4\frac{t-p_{i1}+p_{j1}}{2t})(t + \Delta t) - \Delta V]^2}{18(t + \Delta t)}. \tag{10}$$

Firm i expects the aggregate profits of the two periods as

$$\Pi_i = \pi_{i1} + \delta\pi_{i2}. \tag{11}$$

By simple algebra, the first order condition that maximizes Π_i is

$$\frac{\partial \Pi_i}{\partial p_{i1}} = \frac{t - 2p_{i1} + p_{j1}}{2t} + \delta \frac{5\frac{p_{i1}-p_{j1}}{t}(t + \Delta t) - 3\Delta V}{9t} = 0$$

and the second order condition holds. Solving $\frac{\partial \Pi_A}{\partial p_{A1}} = 0$ and $\frac{\partial \Pi_B}{\partial p_{B1}} = 0$ simultaneously yields the equilibrium period 1 prices:

$$p_{A1} = p_{B1} = t - \frac{2}{3}\delta\Delta V. \tag{12}$$

Since $p_{A1} = p_{B1}$, in equilibrium $\hat{x} = 1$, substituting which into period 1 prices and profits, we easily have the following proposition, where the subscripts A and B are dropped to denote symmetric equilibrium.

Proposition1. The equilibrium results are as follows:

(i) (Advertising strategy) both firms initiate targeted advertising based on consumer purchase history in the second period;

(ii) (Pricing strategy) two firms adopt the same prices:

$$p_1 = t - \frac{2\delta\Delta V}{3}, p_2^o = \frac{2(t + \Delta t) + \Delta V}{3}, p_2^n = \frac{t + \Delta t - \Delta V}{3};$$

(iii) (Equilibrium profit) two firms earn equal profits:

$$\pi_1 = \frac{t}{2} - \frac{\delta \Delta V}{3},$$

$$\pi_2 = \frac{5(t + \Delta t)^2 + 2(t + \Delta t)\Delta V + 2\Delta V^2}{18(t + \Delta t)},$$

$$\Pi = \frac{t}{2} + \delta \frac{5(t + \Delta t)^2 - 4(t + \Delta t)\Delta V + 2\Delta V^2}{18(t + \Delta t)}.$$

With the ability of targeting, both firms advertise in the second period, through which they earn more profits from the old customers, thus enhancing period 2 profits ($\frac{\partial \pi_2}{\partial \Delta V} > 0$, $\frac{\partial \pi_2}{\partial \Delta t} > 0$). However, compared with the case of no advertising, old customers become more important for firms' period 2 profits, which motivate them to price more aggressively in the first period in order to gain more market shares ($\frac{\partial p_1}{\partial \Delta V} < 0$). As a result, firms earn less profit in the first period ($\frac{\partial \pi_1}{\partial \Delta V} < 0$). Therefore, the total profits of the two periods should be further investigated.

3.3 Profit implications

In case of no advertising sponsored ($\Delta t = \Delta V = 0$), the equilibrium profits equal $\frac{t}{2} + \delta \frac{5t}{18}$. Comparing $\Pi = \frac{t}{2} + \delta \frac{5(t + \Delta t)^2 - 4(t + \Delta t)\Delta V + 2\Delta V^2}{18(t + \Delta t)}$ to $\frac{t}{2} + \delta \frac{5t}{18}$, we easily obtain the next proposition.

Proposition 2. Targeted advertising based on consumer purchase history is good for profits if and only if

$$(t + \Delta t)(5\Delta t - 4\Delta V) + 2\Delta V^2 > 0.$$

Proposition 2 indicates that the firm's ability to target advertising with customer recognition does not necessarily benefit profits. We focus on the profit mechanism. Since $\frac{\partial \Pi}{\partial \Delta t} > 0$ and $\frac{\partial \Pi}{\partial \Delta V} < 0$, an increase in Δt is good for profits while an increase in ΔV is bad for profits. The former mitigates period 2 competition as demand curve becomes less elastic, and the latter intensifies period 1 competition due to the two firms' anticipation behaviors. When ΔV is large enough, the loss of period 1 profit dominates the increment of period 2 profit, thereby damaging the total profits. Therefore, we claim that targeted advertising based on consumer purchase history mitigates period 2 competition but aggravates period 1 competition.

3.4 Welfare implications

Finally, we evaluate the welfare effects. For simplicity, in this part we set $\delta = 1$. In the first period, consumers incur a transportation cost $\frac{t}{4}$ on average and receive a gross valuation V . In the second period, consumers incur a transportation cost $\left[\frac{\bar{x} + \hat{x}}{2} + (\hat{x} - \bar{x}) \frac{1 - \hat{x} + 1 - \bar{x}}{2} + (\tilde{x} - \hat{x}) \frac{\bar{x} + \hat{x}}{2} + (1 - \tilde{x}) \left(\frac{1 - \bar{x}}{2} \right) \right] (t + \Delta t)$ on average, which equals $\frac{11(t + \Delta t)^2 - 40(t + \Delta t)\Delta V + 2\Delta V^2}{36(t + \Delta t)}$ by simple algebra, and receive a gross valuation $V + \Delta V$. Since prices have no influence on total welfare, total transportation costs plus gross valuations yields the social welfare (SW):

$$SW = 2V - \frac{t}{4} - \frac{11(t + \Delta t)^2 - 40(t + \Delta t)\Delta V + 2\Delta V^2}{36(t + \Delta t)}. \tag{13}$$

Social welfare minus industry profits (SW - 2Π) yields the consumer surplus (CS).

$$CS = 2V - \frac{5t}{4} - \frac{31(t + \Delta t)^2 - 56(t + \Delta t)\Delta V + 10\Delta V^2}{36(t + \Delta t)}. \tag{14}$$

Similar to Proposition 2, we have the next proposition.

Proposition 3. Targeted advertising based on consumer purchase history is good for social welfare if and only if and good for consumer surplus if and only if

$$(t + \Delta t)(11\Delta t - 40\Delta V) + 2\Delta V^2 < 0,$$

and good for customer surplus if and only if

$$(t + \Delta t)(31\Delta t - 56\Delta V) + 10\Delta V^2 < 0.$$

When ΔV is large enough relative to Δt , although industry profits are damaged, consumer surplus and social welfare are improved. At the other extreme, when ΔV is sufficiently small relative to Δt , targeted advertising boosts industry profits at the expense of consumer surplus and social welfare. This finding is quite intuitive since a larger ΔV means higher consumer valuation which is good for welfare, and a larger Δt means higher transportation cost which is bad for welfare. Besides, we find the possibility that targeted advertising may enhance both industry profits and consumer surplus, thereby achieving a Pareto improvement throughout the entire market, for example, when $\Delta t = \Delta V$.

Proposition 2 and Proposition 3 together suggests that firms in competing environments carefully design the advertising contents. If the advertising is inclined to lay stress on the high value of its product to increase consumer valuation, competing firms may fall into the trap of "prisoners' dilemma" to

compete aggressively in the initial period. On the other hand, if the advertising tends to help consumers distinguish between its own product and other brands, firms can earn more profits by extracting more surpluses from end consumers. From the perspective of some public sector, firms should be guided to display appropriate advertising contents to benefit all members in the market.

4. Conclusion

A simple model is established to investigate the effects of targeted advertising based on consumer purchase history. We show that the firm's ability to target advertising toward its old customers may be bad for industry profits, and does not necessarily be good for social welfare as well as consumer surplus. The reason lies in that in anticipation for a higher profit in the second period caused by targeted advertising, the two firms compete more aggressively to gain a larger market share in the first period, thus resulting in softer competition in the second period but in fiercer competition in the first period. Depending on whether the consumer valuation increasing effect outweighs the product differentiation increasing effect that persuasive advertising plays, it is possible that industry profits, consumer surplus, and even social welfare are damaged by targeted advertising. It is suggested that firms in competing environments carefully design the contents of advertising.

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