How does dominance and competition affect the use of consumer information? Evidence from a famed field experiment

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Abstract

Strategic customer poaching is widely prevalent however, the aggressiveness in pricing strategies varies across markets. We present stylized models of strategic interaction in symmetric duopoly, asymmetric duopoly and multiple firm markets to compare the impact of firm size and number of firms on pricing strategies given customer recognition. To gain real world insights we conduct a framed field experiment with an expert pool of pricing professionals as subjects and validate theoretical predictions. In contrast to conventional wisdom, our results suggest that compared to dominant firms in asymmetric markets, symmetric duopolists are more aggressive while firms competing against multiple competitors adopt the least aggressive pricing strategy. Our results suggest that increasing competition could be a more effective means of improving consumer welfare compared to regulating dominant firms. Furthermore, as firms gain access to more information price discrimination increases, however, customer welfare is reduced as fewer customers are served in equilibrium.
1 Introduction

Customer recognition is widely prevalent today with firms increasingly using novel ways of collecting customer information. It is estimated that in 2012, 77% of US customers carried at least one loyalty card with an average of 8.4 cards per household (Colloquy, 2012). The high penetration of loyalty cards has given firms access to vast amounts of granular demographic and behavioral customer data, while the simultaneous decline in the cost of storing and analyzing data has made targeted pricing feasible. This raises the question of how improved customer recognition impacts prices. Recently, at a Safeway supermarket in Denver USA, a pack of bottled water was priced at $2.71 for customer A, while customer B was charged $3.69 for the same pack (Clifford, 2012). Customer A had not purchased the bottled water in the past and was charged a lower price, while customer B who had purchased the water at previous shopping trips was charged a higher price. Price discrimination based on consumers’ past purchase history is regarded as behavior based price discrimination (BBPD). The Harvard Business Review (2011) predicts that store recommendations and customized price offers will be the norm in the future. While BBPD is widely prevalent across competitive markets, pricing strategies vary across markets. For instance, it is common practice among mobile operators to create high switching costs for existing customers, in contrast, banks often offer existing customers preferential lending rates.

Given the popularity of BBPD, a growing literature studying price discrimination in dynamic models of strategic interaction has emerged (see Fudenberg and Villas-Boas, 2006 for a detailed survey). Equilibrium outcomes in these models are dependent on specific modeling assumptions and diverge in their predictions regarding the impact of BBPD on prices, profits and consumer welfare. For instance, market outcomes vary with assumptions regarding market dominance (e.g. Chen, 2008), consumer preferences (e.g., Chen and Pearcy, 2010), switching costs (e.g., Chen, 1997; Shaffer and Zhang, 2000) and customer heterogeneity (e.g., Shin and Sudhir, 2010; Gehrig et al., 2007). As noted by Amaldoss et al. (2008), theoretical models of strategic interaction are well developed in the marketing literature, however, the empirical validation of theoretical predictions is limited.

Through this study we aim to reconcile differences in observed pricing behavior across industries by comparing the effect of competitiveness (number of firms) and dominance (size of firms)
on pricing strategies. We present stylized models of dynamic strategic interaction across symmetric duopoly markets, asymmetric duopoly markets and markets with multiple symmetric firms, to address the following questions: How do market dominance and competitiveness impact prices? Does increase in the number of firms incentivize price discrimination? Are small firms more aggressive in pricing strategies or do large firms exploit their dominant position?

We further bridge the gap between theory and practice by testing the validity of the causal factors through a framed field experiment.1 Ours is one of the first studies that tests the impact of market dominance and competition on pricing strategies using an expert pool of pricing professionals from diverse industries in a field setting. Since detailed data on pricing is difficult to obtain, an experimental setting not only replicates real world pricing scenarios but simultaneously allows for a better understanding of the motivation behind the choice of pricing strategies. An experimental setting is particularly suited to our study as it controls confounding factors (e.g. strategic customer behavior, asymmetric information and differences in costs of production) enabling us to determine the impact of dominance and competitiveness in isolation, providing internal validity. We also use our strategic game to explore the impact of improved customer recognition on prices and customer welfare.

Based on the behavior of our expert subject pool, we find that an increase in competition reduces the prevalence of price discrimination. Participant behavior is consistent with the practice of sign up discounts in concentrated markets (e.g. cable television) and the proliferation of loyalty reward schemes in the competitive industries (e.g. retail). Similarly, the aggressiveness2 in pricing strategy varies with market dominance. We observe that symmetric duopolists adopted the most aggressive poaching strategy with huge discounts to new customers and high premiums to existing customers. In contrast to popular wisdom, dominant firms in asymmetric markets were not as aggressive in their pricing. Small firms in the asymmetric and multiple firm market adopted the least aggressive strategy and discouraged customer switching by offering similar prices to existing and new customers. Our results have useful policy implications; our findings suggests that government regulation targeting dominant firms may not protect consumers from exploitation from multiple large firms. Based on our findings competition authorities could encourage competition in markets

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1See Harrison and List (2004) for a detailed discussion on the taxonomy of field experiments.
2We define the difference in price to existing and new customers as a measure of price aggressiveness, details are outlined in Section 4.
to increase customer participation rather than legislating against dominant firms in asymmetric markets.

We also find that customer information affects the decision to price discriminate. When participants were given access to more detailed information regarding willingness to pay, discrimination increased across all market conditions. However, additional information resulted in higher prices and lower market coverage, making customers worse off. Hence, advancement in customer recognition does not necessarily make customers better off and customer privacy must be protected.

The remainder of this paper is organized as follows: Section 2 summarizes the developments in the literature on BBPD, Section 3 presents the analytical model while Section 4 outlines the main hypothesis to be tested, Section 5 outlines the experimental procedure and design, Section 6 presents the findings of the experimental study and Section 7 presents a discussion of the key findings and policy implications.

2 Literature Review

Over the past decade a diverse literature has emerged studying price discrimination in markets with customer recognition. Most studies consider price discrimination in symmetric duopoly markets, where each firm has sufficient market power and therefore acts strategically in response to rival’s pricing strategy. A dominant theme in the literature is that customer recognition coupled with constant consumer preferences results in intense competition to attract new customers through switching discounts, while consumer surplus is extracted from existing customers (e.g., Fudenberg and Tirole, 2000; Pazgal and Soberman, 2008; Chen and Zhang, 2009). However, the outcome of BBPD is dependent on specific modeling assumptions. For instance, Chen and Pearcy (2010) introduce price commitment and preference stochasticity to show that loyalty rewards can be profitable. While Shin and Sudhir (2010) suggest that customer stochasticity and heterogeneity are pre-requisites for profitable customer retention strategies.

Equilibrium outcomes also depend on market dominance. For instance, Chen (2008) considers an asymmetric market where the firm with the stronger brand eliminates competition by adopting an aggressive poaching strategy. In contrast, Gehrig et al. (2006) find that the smaller firm engages
in aggressive customer poaching to gain market share. Shaffer and Zhang (2000) also consider asymmetry in a duopoly model and find that asymmetric switching costs are sufficient to make a customer retention strategy profitable.

While the literature on BBPD in the context of duopolies is fairly well developed, strategic interaction between multiple firms has received limited attention. According to Fudenberg and Villas-Boas (2006) with multiple firms the implications for the profitability of firms are less obvious. Taylor (2003) contends that with more than two firms, each firm faces the threat of customer poaching from at least two rival firms, the increase in price competition could even result in prices being set below cost to attract new customers, while some rents may be extracted from existing customers.

Thus, the impact of BBPD on prices and consumer welfare is dependent upon specific modeling assumptions. The difficulty in obtaining detailed pricing data at the industry level makes empirical validation of theoretical predictions difficult. Furthermore, extant research on BBPD has not considered how the incentives for price discrimination change when market structure changes. In order to compare price discrimination across size and number of firms, we extend Fudenberg and Tirole (2000) dynamic model of strategic interaction with homogenous products to competition with asymmetric and multiple firms. Through our experimental study we contribute to the existing literature on BBPD by not only testing the validity of theoretical predictions but we also provide insights on how real world pricing experts react to dominance and competition.

In addition, we explore the impact of customer information on price discrimination. Esteves (2009) shows that the profitability of price discrimination depends on the type of information available to firms and not all information results in a prisoners dilemma. We therefore, empirically test the impact of the availability of more detailed information on customer willingness to pay pricing strategies.

Our paper also contributes to the experimental literature on pricing in competitive markets. There has been a long tradition of using experiments to study price competition (e.g. Mahmood, 2013; Morgan et al., 2006; Baye and Morgan, 2004; Dufwenberg and Gneezy, 2000; Hoggatt et al., 1976; Smith, 1962 ). Mahmood (2013) is the only other experimental study that deals with price competition in a dynamic two period market with customer recognition. While Mahmood (2013) focuses on the impact of customer characteristics (heterogeneity and preference stochasticity) on
pricing in symmetric duopolistic markets with student subjects, we consider the impact of dominance and competition on pricing with professional participants in a framed field experiment. The impact of market concentration on competition has been studied in a laboratory context by Dufwenberg and Gneezy (2000) and Dufwenberg et al. (2007). Dufwenberg and Gneezy (2000) show that competition intensifies as the number of players increases in a Bertrand oligopoly game. Similarly, Dufwenberg et. al., (2007) find that anti-competitive price floors in Bertrand models foster competition and may lead to lower prices under conditions of duopoly, but not so in quadropoly. Hence, there is experimental evidence suggesting difference in pricing behavior as market dominance and concentration change. However, these studies focus on static markets where customer recognition is not possible.

3 Theoretical Setup

In this section we briefly describe three different models that underlie our experimental design; symmetric duopoly, asymmetric duopoly and competition amongst multiple firms. We consider a two period model of dynamic competition between strategic forward looking firms. Firms are located in a market of unit length and strategically set prices across two periods to maximize total profits subject to per unit cost of production $c^3$. Following Fudenberg and Tirole (2000), in Period 1 firms are unaware of the preferences of customers and therefore, can only charge a uniform price to all customers. In Period 2 firms learn about consumer preferences based on Period 1 purchase behavior, in light of this information firms have the option to discriminate between existing and new customers. Consumers are assumed to be rational per period utility maximizers with inelastic unit demand and constant preferences over time. The main source of customer heterogeneity is the intrinsic preference for a firm (horizontal differentiation), which is defined in terms of consumer location in the market. Customers are assumed to face a per unit transportation cost of $t$. In this section we present analysis of prices, details of profit can be found in Appendix A.

\[\text{Cost of production are identical across firms.}\]
3.1 Symmetric Duopoly

Following Fudenberg and Tirole (2000), two symmetric firms A and B are located at opposite ends of the market. Due to the dynamic nature of the game firms set Period 2 prices based on the market share in Period 1 (firm A’s Period 1 market share is defined by \( x \), while firm B’s market share is \( 1 - x \)). Starting the analysis in Period 2 and considering the interior solution, optimal prices in Period 2 are as follows (details of the derivation can be found in Appendix A):

\[
\begin{align*}
    p_{2A}^A &= c + \frac{t(1 + 2x)}{3}, \\
    p_{2B}^A &= c + \frac{t(3 - 4x)}{3}, \\
    p_{2A}^B &= c + \frac{t(4x - 1)}{3}, \\
    p_{2B}^B &= c + \frac{t(3 - 2x)}{3}
\end{align*}
\]

The above prices show that the loyalty premium increases with the inherited market share from Period 1, while the poaching price offered to rival’s customers decreases with the inherited market share. Thus, if firms have a large inherited market share they resort to extraction profits, however, if the inherited market share is small, firms encourage customer switching by offering discounts to new customers.

We solve for Period 1 prices assuming firms set prices to maximize total profits, while myopic consumers only maximize Period 1 utility. This results in a symmetric equilibrium where

\[
p_1^A = p_1^B = c + t
\]

Both firms have equal market share in the first period i.e., \( x = 0.5 \). This equilibrium outcome is similar to the equilibrium in a single period game, as both firms try to maximize Period 1 market share to ensure profitable discrimination in Period 2. Consequently, Period 2 equilibrium prices are:

\[
\begin{align*}
    p_{2A}^A = p_{2B}^B &= c + \frac{2t}{3}, \\
    p_{2A}^B = p_{2B}^A &= c + \frac{t}{3}
\end{align*}
\]

In Period 2 customer recognition results in customer poaching behavior; firms offer discounts to new customers and charge higher prices to existing customers. Due to the competitive effect of
customer poaching we observe that prices decline in Period 2 \( (p_1^A > p_2^{AA} > p_2^{AB}) \). Furthermore, we expect a decline in profits across time due to the competitive effects of customer poaching.

### 3.2 Asymmetric Duopoly

In this model we consider competition between a dominant firm and a small firm. We assume the dominant firm (firm A) is located in the center of the market while the small firm (firm B) is located at the end of the market. The market can be viewed as being divided between customers loyal to the dominant firm and a segment of switchers. We set the mass of the loyal segment equal to \( l \), such that \( 0 < l < 1 \). The firms compete over the the \( 1 - l \), segment of switchers. Bouckaert et al. (2008) use a similar set up to define asymmetric competition. The dominant firm maximizes its profits over the competitive and loyal segment, while the small firm only maximizes profits over the competitive segment. Solving the F.O.C.s with respect to Period 2 prices we get the following interior solution for Period 2 prices.

\[
\begin{align*}
  p_2^{AA} &= c + \frac{t(2x' + 4l + 1)}{3}, \\
  p_2^{BA} &= c + \frac{t(3 - 4x')}{3}, \\
  p_2^{AB} &= c + \frac{t(4x' + 2l - 1)}{3}, \\
  p_2^{BB} &= c + \frac{t(3 - 2x')}{3}
\end{align*}
\]

(4)

Similar to the symmetric case, Period 2 prices are dependent on Period 1 market share. For the dominant firm the price charged to existing customers is also positively related to the size of the loyal segment, the larger the size of the loyal segment, the higher the loyalty premium in Period 2. Similarly, for the small firm, if \( l \) is large the small firm does not offer poaching discounts as the chances of customers switching to the small firm are low. However, the price charged to rival’s customers depends on Period 1 market share, for both firms the higher the Period 1 market share the surplus is extracted from existing customers.

In Period 1 myopic consumers only consider the current period prices offered by the two firms. Solving for Period 1 prices results in the following equilibrium prices:

\[
\begin{align*}
  p_1^A &= t + \frac{t(4l(81 - 99\delta - 40\delta^2))}{9(27 - 20\delta)} + c, \\
  p_1^B &= t + \frac{t(2l(81 - 198\delta - 80\delta^2))}{9(27 - 20\delta)} + c
\end{align*}
\]

(5)
where $\delta$ denotes the discount rate.

Our analytical model suggests that in Period 1 the dominant firm sets higher prices compared to the smaller firm i.e., $p_{1}^{A} > p_{1}^{B}$. While the dominant firm takes advantage of its market power and extracts consumer surplus, the small firm offers lower prices to capture market share. Consequently, in Period 1 the dominant firm captures less than half of the competitive segment. While customers are worse off, the small firm benefits from the dominant firm’s high price by keeping its Period 1 price higher than the symmetric price ($p_{1}^{A} > p_{1}^{A}$ and $p_{1}^{B} > p_{1}^{B}$). Finally Period 2, prices are:

$$p_{2}^{AA} = c + \frac{2t}{3} + \frac{2lt(45 - 40\delta)}{81 - 60\delta} > p_{2}^{AA}$$
$$p_{2}^{BB} = c + \frac{2t}{3} + \frac{18lt}{81 - 60\delta} > p_{2}^{BB}$$
$$p_{2}^{RA} = c + \frac{t}{3} + \frac{36lt}{81 - 60\delta} > p_{2}^{RA}$$
$$p_{2}^{AB} = c + \frac{t}{3} + \frac{2lt(9 - 20\delta)}{81 - 60\delta} > p_{2}^{AB}$$

(6)

Given $\delta < 0.45$ (i.e. the future is not heavily discounted), the dominant firm adopts an aggressive pricing strategy in Period 2 as it attempts to increase its market share in the competitive segment. The dominant firm simultaneously maximizes its extraction profits by charging a high loyalty premium to customers in the competitive and captive segments. Due to the dominant firm’s high price to existing customers the small firm does not have to offer very deep discounts to induce switching. As a result the small firm engages in limited price discrimination between existing and new customers. Pazgal and Soberman (2008) also find that in the presence of aggressive poaching by a dominant firm, it is in the best interest of the weak rival to not engage in price discrimination. As a consequence of the aggressive price discrimination the dominant firm’s market share in the second period in the competitive segment increases from Period 1 to Period 2 ($x' < \alpha + \beta - x'$).

Compared to the symmetric market, firms are better off as both the dominant and small firm are able to charge higher prices. From a small firm’s perspective it is better to be a small firm in an asymmetric market than a highly competitive market.
3.3 Four Firms

Following Salop’s (1979) circular city specification, we model multiple firm competition as a monopolistic competitive market. In the interest of simplicity we assume that four firms A, B, C and D are located at equal intervals in the market. Each firm competes with at least two neighboring firms, one on the right and one on the left. Solving the Period 2 F.OCs and assuming symmetry we get:

\[
p_{2,\text{exist}} = c + \frac{t}{4} - \frac{2tx''}{3} \tag{7}
\]

\[
p_{2,\text{new}} = c + \frac{t}{4} - \frac{4tx''}{3}
\]

The outcome is similar to the symmetric duopoly scenario, whereby price offered to new customers is lower than the price to existing customers. Period 1 prices given rational and myopic buyers are:

\[
p_{1,A} = p_{1,B} = p_{1,C} = p_{1,D} = c + \frac{t}{4} \tag{8}
\]

All firms equally share the market in Period 1, which implies that \(x'' = 0.25\).

The resulting Period 2 equilibrium prices are:

\[
p_{2,\text{exist}} = c + \frac{t}{6} < p_{2,AA} \tag{9}
\]

\[
p_{2,\text{new}} = c - \frac{t}{12} < p_{2,AB}
\]

Equilibrium with multiple firms results in lower period 2 prices compared to the symmetric case. In addition, compared to symmetric markets the gap between price to new and existing customers is reduced.
4 Testable Implications

In this section we present the hypotheses that we test in our experiment.

Our theoretical models suggest that pricing behavior is sensitive to dominance and competition. While we expect to see customer poaching across all scenarios, the average prices are expected to be highest in the asymmetric duopoly market followed by the symmetric duopoly market and lowest in the multiple firm market (see eq. (2), eq. (3), eq. (5), eq. (6), eq. (8) and eq. (9)).

• H1: \( \text{Price}_{\text{Asymmetry}} > \text{Price}_{\text{Symmetric-Duopolist}} > \text{Price}_{\text{Multiple Firms}} \)

Since price discrimination is dependent on Period 1 market share, we expect more discrimination in concentrated markets and less discrimination when markets become more competitive.

• H2: \( \text{Discrimination}_{\text{Duopolist}} > \text{Discrimination}_{\text{Multiple Firms}} \)

Likewise in asymmetric market, due to its larger inherited market share we expect the dominant firm to engage in more price discrimination compared to the smaller rival.

• H3: \( \text{Discrimination}_{\text{Dominant}} > \text{Discrimination}_{\text{Small}} \)

When customers are homogenous and preferences are stable, we expect prices for new customers to be lower than prices offered to existing customers. Following from equations (3), (6) and (9) we expect BBPD to result in customer poaching:

• H4: \( \text{Price}_{\text{Existing Customers}} > \text{Price}_{\text{New Customers}} \)

We expect the degree of aggressiveness in price discrimination to vary across markets. We define aggressiveness as the premium charged to existing customers over and above the price charged to new customers in Period 2. Based on the analysis in the previous section, we expect dominant firms to offer deeper discounts to rival’s customers to increase market share in the competitive
segment, while simultaneously charging high loyalty premiums to existing customers. In contrast, the small firm in the asymmetric market protects its market share in the second period by offering competitive prices to existing customers. Similarly, in markets with multiple firms each firm has a smaller share of the total market and risks losing its market share to multiple rivals, therefore as competition increases, firms adopt the least aggressive pricing strategy.

- **H5**: Aggressiveness_{Asymmetry-Dominant} > Aggressiveness_{Symmetric Duoplist} > Aggressiveness_{Asymmetry-Small} > Aggressiveness_{Multiple Firms}

Experiments not only provide a means of testing theoretical predictions of economic models but also allow for additional behavioral insights. Therefore, we present additional hypotheses regarding the impact of increased customer information on price and market coverage.

According to Stole (2007) incentives for discrimination exist when (i) firms have short-run market power, (ii) no arbitrage opportunities exist and (iii) consumers can be segmented directly or indirectly. Therefore, any additional information that aids in customer segmentation is expected to result in greater price discrimination. We hypothesize that participants will use the additional information on customer types to set personalized prices for existing customers

- **H6**: Improved customer recognition increases price discrimination

We further contend that the ability to discriminate on the basis of customer type is not detrimental to consumer welfare. When firms use additional information to improve customer targeting based on willingness to pay, it is expected to result in greater market coverage compared to the partial information condition as customers with low willingness to pay can be included in the market without forgoing additional revenue from the high type customers. Therefore, we hypothesize that increased ability to differentiate between customers is mutually beneficial for customers and firms.

- **H7**: Customers are better off on average when firms have information on customer type
5 Experiment Design

5.1 Subjects

Participants were recruited from Business School alumni networks, executive MBAs and members of professional pricing societies. We recruited professionals with at least one year experience in setting prices and promotional activities in competitive industries like fast moving consumer goods, telecoms, banking, retail, utilities and consulting. Subjects were invited to share their real world experience and make contribute to academic research. Participants actively responded through email and appeared sufficiently motivated to facilitate the understanding of pricing in dynamic markets.

78% of the participants were men and 75% had an MBA degree. Around 47% of participants stated they belonged to large firms with over 1,000 employees and 70% of the participants belonged to industries with high competition. 60% of respondents stated that pricing and promotions were important for their industry. 45% of the respondents stated their firm followed a pricing strategy similar to their competitor, while 31% noted that their firm had an innovative pricing strategy. Thus recruited participants were familiar with price setting in competitive scenarios.

5.2 Experiment

We employ a within subjects design with three market scenarios; symmetric duopoly, asymmetric duopoly and multiple firms. The markets are defined as follows:

- **Symmetric duopoly**

  The market is modeled as a linear city with two sellers A and B located at opposite ends of the city. A-priori there are equal number of customers close to each seller.

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4 Frechette (2011) defines professionals in experimental contexts as people working in an industry where the game under study is relevant.

5 Geographical proximity can be interpreted in terms of store loyalty.
• Asymmetric duopoly

The market is modeled as a linear city with the dominant seller located in the center of the market and the small seller located at the end of the city. 75% of the market is closer to the dominant seller, while only 25% of the customers are in close proximity to the small seller.

• Four firms

The market is modeled as a circular city, with four sellers located at equal intervals. Each seller is conveniently located for 25% of the market.

Each week participants were asked to participate in a different market scenario and the order was randomized to control for any reference effects.

In addition, we divided participants into two information conditions: full information and partial information. In the full information treatment participants could distinguish between existing high and low type customers, and could therefore, personalize prices by customer type. In the partial information treatment participants could only offer a single price to existing customers. At the beginning of the experiment participants were equally divided into the full information and partial information conditions. The between subject manipulation of information conditions mitigated potential demand effects.

5.3 Procedure

Our experimental setting follows a naturally occurring pricing scenario familiar to participants so that the strategic interaction occurs endogenously. To accommodate the busy schedule of working professionals we conducted all experimental sessions online. Online correspondence with participants has been gaining popularity due to its convenience, especially for specialist subject pools (e.g., Artinger and Vulkan, (2012) accommodate the busy schedule of entrepreneurs with an online experiment). Horton et al. (2011) present a detailed discussion regarding the merits of online platforms and note that online experiments in addition to eliminating travel costs and pro...
viding convenience to participants, mitigate any demoralization that may occur in a lab setting due to knowledge regarding other participants or experimenter effects. Similarly, Buhrmester et al. (2011) find no difference in the data collected from online sources and data obtained via traditional methods.

Participants were sent weekly emails with instructions regarding the competitive scenario and the rules of the game (detailed instructions can be found in Appendix B). Participants were informed that they were taking part in a two period game with one (three) competitors and their primary task was to set prices in each period to maximize their profits.

Our experimental setting allowed for both vertical and horizontal differentiation amongst customers. Participants were informed that 2,000 customers were evenly distributed across the 20-mile market with 100 customers at each unit interval. Sellers were informed that buyers incurred transportation costs to travel to the store. The location of buyers is crucial in our design and represents their intrinsic preference for a particular seller. Other spatial price experiments have also defined buyer preferences in terms of transportation costs (e.g. Mahmood, 2013; Orzen and Sefton, 2008; Selten and Apesteguia, 2005). Buyers also differed in their valuation for the experimental product, (vertical differentiation), half of the market comprised of high valuation buyers while the other half consisted of low value buyers.

We use robot buyers who were programmed to minimize per period expenditure, i.e buyers were rational and myopic. In our experimental setting we relax the assumption of complete market coverage, and allow for equilibrium outcomes in which some customers are not served.

Participants were informed that they would be competing against randomly matched experiment participants. Participants were matched within the information conditions, i.e. a participant assigned to the full information condition only played against other participants in the full information condition. Once participants made Period 1 pricing decision, emails with feedback on Period 1 market share, competitor’s Period 1 market share, Period 1 own price, competitor’s Period 1 price and Period 1 profit were sent out the following day.

In Period 2, sellers had the option to personalize prices based on buyer’s behavior in Period 1. In Period 2, participants assigned to the partial information condition were asked to set prices

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6 The experimental product was defined as electronic brush heads. These products were selected because their retail prices were in the range of prices outlined in the experiment.
for existing customers and new customers, while participants in the full information condition were given the option of setting three different prices; (i) price to high type existing buyers, (ii) price to low type existing buyers and (iii) price for new buyers. Once all participants had submitted the Period 2 prices participants were contacted in the following week with a request to participate in a different market condition.

To ensure participants fully understood the rules of the experiment, in week 1 all participants were asked to play a trial round. Furthermore, to allow participants an opportunity to learn about the competitive nature of the game, participants were given the option to play against a computer-simulated competitor each week. Once participants had understood the rules of the game they proceeded to make actual pricing decisions. Participants played the game only once. While other experiments often play multiple rounds to ensure equilibrium play, it has been noted that multiple round games can result in repeated game effects such as increased cooperation amongst participants (see Pearce, 1992; Friedman, 1977). Furthermore, we expect the outcome of the experiment to reflect a market in equilibrium as participants have significant real world experience in setting prices.

Experimental sessions lasted around half an hour. At the end of the game two randomly selected participants were made payments based on their performance in the game. Every £1 earned in the game was worth 5p in the real world. The two selected participants earned £264 and £227.  

6 Results

In this section we outline the main findings of our experimental study. A total of 89 participants took part in the experiment and 45 participants played all market scenarios. 44 participants were randomly assigned to the full information condition while 45 participants were given only partial information about the type of their existing customers. A total of 62 subjects participated in the symmetric duopoly scenario, while 66 subjects participated in the asymmetric duopoly scenario and 70 subjects took part in the multiple firm scenario (see Table 1 for details).

While we had intended to complete each session in a week, due to the busy schedule of some

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7Only participants who had completed all experimental scenarios were short listed to receive payment.
participants the deadlines were extended and the experiment lasted a total of four weeks. During this time period some participants dropped out of the experiment and 44 participants completed all three market scenarios. Of these 44 participants, 26 participated in the partial information condition while the remaining 18 were assigned to the full information condition (see Table 2 for details of participant drop out). We conducted detailed drop out analysis (see Widaman, 2006 for details) on the responses of participants who completed all scenarios and those who completed only one or two scenarios. Based on t-tests for prices entered by participants we find no statistically significant difference in the responses of either group of participants. In addition statistical analysis for participants who completed all scenarios was compared to the results of all participants and no difference in behavior was observed (details of comparison tests can be requested from the authors). Therefore, we do not suspect any systematic difference in the behavior of participants who dropped out before completing all three scenarios.

### 6.1 Prices across Scenarios

Since the experimental tasks closely mimic real world scenarios faced by professionals, we find evidence of strategic price setting behavior. Table 3 compares average prices across periods and scenarios. Comparison of the average price offered to new and existing customers reveals that prices decline over time. Figure 1 plots the offer prices across market scenarios. The plots show that across all market scenarios participants offered lower prices when price discrimination was possible in Period 2. This suggests that the competitive effect of price discrimination outweighs the surplus extraction effect across all market scenarios.

While there is no statistically significant difference in average Period 1 prices across scenarios, prices vary across scenarios in Period 2. Based on a one-way ANOVA prices to existing customers differ across scenarios ($F_{2,106} = 3.01, p < 0.06$). In Period 2 prices offered to existing customers are the lowest for the multiple firm scenario, followed by the asymmetric scenario, while the symmetric duopolists offer the highest prices to existing customers.

While there is no difference in prices due to market dominance, competition results in lower prices to existing customers ($diff = 4.27, t = 2.79, d.f = 28$). Similarly, market structure influences
prices offered to new customers \((F_{2,398} = 6.19, p < 0.01)\). However, new customers are on average offered the same price in the symmetric duopoly scenario and the multiple firm scenario \((\text{diff}=0.07, t = 0.06, d.f=28)\). Figure 1 highlights that few participants set low prices in the symmetric duopoly scenario, while the majority of participants offered similar prices to new and existing customers in the multiple firm scenario. Therefore, we do not find support for \(H1\), prices on average drop with increased competition, however the impact of dominance is on average not significant.

6.2 Determinants of Price Discrimination

Consistent with \(H2\), we find that the difference in the proportion of participants engaged in price discrimination declines with the number of firms \((z = 2.03, p < 0.05)^8\). This result suggests that when multiple firms compete for the same customers, the incentive to poach competitor’s customers declines. Since each firm’s market dominance is diluted firms are unable to earn extraction profits to compensate for lost profits from aggressive poaching.

Comparison of small and dominant firms in the asymmetric scenario reveals that price discrimination also depends on ex-ante market dominance. Based on Wilcoxon rank-sum test we find that that dominant firms engage in more price discrimination compared to small firms \((z = 2.44, p < 0.02)^9\). According to Figure 2, 56.3% participants assigned the role of small firms in the asymmetric scenario do not discriminate between customers. In contrast, participants assigned the role of dominant firms price discriminate 72.5% of the time. Our results confirm \(H3\), as dominant firms are more likely to engage in price discrimination compared to smaller firms. In line with Bouckaert et al. (2008), in Period 2 dominant firms expand market share by offering discounts to competitor’s customers, whereas the smaller firms protect market share.

We further analyze the pricing behavior to determine the factors influencing the decision to price discriminate. Using a binary logit specification we regress discrimination (the dependent variable takes the value of 1 if the participant offers different prices to existing and new customers

---

8 Based on the Wilcoxon rank-sum test

9 Test with participants who completed at least 2 scenarios.
in Period 2, and 0 otherwise)\textsuperscript{10} on indicator for firm size, number of firms, information dummy and controls for participant random effects. Table 4 contains regression results.

We find that the incidence of discrimination declines in the market with multiple competitors. However, participants increase discrimination when full information on the type of existing customers is available. In addition, we observe participants display heterogeneity in their price setting behavior, 20% of the observed variance in behavior can be explained by participant level heterogeneity. The underlying reasons for this observed heterogeneity in pricing strategy could be a reaction to the strategy of their rival in the game or their industry know how. Despite controls for individual level effects we observe that information, dominance and competitiveness significantly influence the decision to adopt a discriminatory pricing strategy.

### 6.3 Price Discrimination results in Customer Poaching

In line with $H4$, BBPD on average results in lower prices for new customers and higher prices for existing customers. Table 5 provides a comparison of average prices offered to existing and new customers across market scenarios. According to Table 5, competition between multiple firms results in no significant difference between prices offered to existing and new buyers. To better understand participant behavior, we compare the percentage of participants that offered discounts to existing customers (retention strategy), percentage that offered discounts to new customers (acquisition strategy) and the proportion of participants that offered both groups the same price (no discrimination). We report the findings in Figure 2. When competition is symmetric, participants adopt a poaching strategy and offer discounts to new customers and charge high prices to their existing customers. Similarly, there is greater customer poaching under the asymmetric scenario, however, the incidence of discrimination decreases. While in duopolistic markets majority of participants adopt a poaching strategy (53% in the symmetric market and 42% in the asymmetric market), in the multiple firm scenario only 30% adopt a poaching strategy and 58% of the time old and new customers are offered similar prices. Hence, when market share is diluted participants are

\textsuperscript{10} We compute this variable across the two information conditions and market scenarios.
more likely to pay their customers to stay.

### 6.4 Aggressiveness across Scenarios

We measure aggressiveness as the difference between the price offered to existing and new customers. Figure 3a shows the box plot for aggressiveness across scenarios and Figure 3b presents the average aggressiveness across firm size in the asymmetric scenario.

We find that aggressiveness in poaching behavior varies across market scenarios ($F_{2,106} = 5.35$, $p < 0.01$). The maximum observed difference in prices to existing and new customers is under the symmetric duopoly scenario followed by the dominant firm in the asymmetric scenario. Based on our sample of participants the most aggressive poaching is practiced when firms have ex-ante equal market dominance, while dominant firms in asymmetric markets are not as aggressive as theory predicts. Furthermore, in the asymmetric scenario in the face of the dominant participant’s aggressive poaching strategy the small participant offers similar prices to both existing and new customers.

For the full information scenario we define aggressiveness as the difference between the price charged to high type existing customers and new customers, as well as the difference in price to low type existing and new customers. Figure 4a presents the distribution of the aggressiveness in poaching behavior across markets. Similar to the partial information treatment we observe the duopoly firms to be most aggressive with little variation in behavior across participants. There is less discrimination in the asymmetric scenario and the least discrimination with multiple firm competition. However, there are some outlying participants who set very aggressive prices. It is also interesting to note that compared to the partial information condition there are less instances of customer retention (the measure of aggressiveness almost always takes a positive value), and existing high type customer are charged higher prices than existing low type customers.

Comparison of aggressiveness across size in the asymmetric market with full information (see Figure 4b), reveals that the dominant sellers are more aggressive in their pricing strategy. While small sellers offer less of a price differential between existing high and low prices. Hence, our

---

11 Based on all participants in the partial information condition.
experimental results do not support $H5$. We find that that sellers operating in a symmetric duopoly market are the most aggressive followed by dominant firms in an asymmetric market, while multiple small sellers are the least aggressive.

We further analyze the reasons for the aggressiveness using mixed model regression analysis with participant random effects on data pooled across market scenarios in the partial information condition. The results are presented in Table 6. Our results confirm economic theory (e.g., Fudenberg and Tirole, 2000) as the primary motivation behind customer poaching appears to be an expansion of market share. If Period 1 prices are high participants engage in aggressive customer poaching to gain market share in Period 2. Participants discriminate more aggressively if Period 1 market share of high type customers is high, while discrimination is less aggressive if Period 1 market share of low type customers is high. This suggests that participants extract consumer surplus from the existing high type customer base while offering steeper discounts to attract low type rivals customers.

6.5 Impact of Information

When participants are given information on the purchase history of existing customers by type, participants engage in greater price discrimination compared to the partial information condition. Across all market scenarios price discrimination increases from 54% to 70% when participants have the option to discriminate on the basis of customer willingness to pay (see Figure 5). Based on Two-sample Wilcoxon rank-sum, price discrimination increases when full information regarding customer types is revealed ($z = -1.97$, $p < 0.05$). Therefore, we find evidence supporting $H6$.

Comparison of offer prices across markets in the full information treatment reveals that similar to the partial information treatment, participants in the multiple firm scenario offer lower prices compared to the duopoly markets (see Figure 6). In addition, we observe that in the multiple firm scenario most participants offer similar prices to existing and new customers, however, in the duopoly markets, especially the symmetric duopoly, the price to existing customers is above the price offered to low type customers and new customers.
6.6 Customer Recognition is Welfare Reducing

In order to determine the impact of customer information on consumer welfare we compare the market coverage across the full information and partial information treatments. Figure 7 compares the market share across information conditions. Contrary to hypothesis $H7$, greater information does not result in greater market coverage. Instead more customers are served when firms have partial information.

The lower market coverage can be explained by the higher prices under the full information treatment compared to the partial information treatment. Figure 8 summarizes the average prices across the two treatments. When participants are allowed to discriminate by customer type, the price to existing customers is on average higher than the partial information treatment. In addition, the price offered to new customers is also higher. Thus, information about customer types not only results in greater surplus extraction from existing customers but also reduces the competitive pressure of customer poaching. While firms benefit from information customers are not necessarily better off and $H7$ does not hold.

7 Discussion

We contribute to the literature on BBPD by presenting a framed field experiment that explores the interaction between the size of firms and number of firms in markets with customer recognition. Through our experiment we test BBPD in a number of common market scenarios which define many industries (e.g., subscription markets, retail, insurance, telecommunications and utilities).

Our sophisticated subject pool of pricing professionals highlights the significance of purchase history when setting prices. The findings of our experimental study support theoretical models of BBPD, whereby customer recognition results in customer poaching. However, the prevalence of price discrimination varies with market competitiveness. Firms in duopolistic markets are more likely to discriminate compared to firms competing against multiple competitors. Participants choose to discriminate approximately 62% of the time in duopolistic markets, and only 34% of the time in markets with multiple firms. While the number of competitors reduces the prevalence
of customer poaching, competition increases the proportion of participants adopting a customer retention strategy. This result helps explain why industries with few similar sized firms attract new customers by offering discounts, for instance, Sky digital a dominant cable operator, was offering customers gift vouchers upon signing up for their services. On the other hand, in industries with multiple competitors competing for the same pool of customers like fashion retailers similar prices are offered to new and existing customers.

Furthermore, participant behavior suggests that pricing behavior also varies with market dominance. For instance, in asymmetric markets, large firms are more likely to extract surplus from their existing customers and offer poaching discounts to new customers while smaller firms offer similar prices to new and existing customers. Our results are consistent with the practice of big insurance providers like AA charging existing customers higher premiums while offering discounts to new customer, on the other hand, smaller providers offer similar benefits to new and existing customers.

Contrary to economic theory and conventional wisdom, the observed difference in prices to existing and new customers is on average greater for symmetric duopolists compared to the dominant firm in the asymmetric scenario. This suggests that when firms have equal ex-ante market dominance they act strategically by offering large discounts to rivals customers to expand market share, while simultaneously making up for lost profit by extracting surplus from their existing customer base. On the other hand, the dominant firm in asymmetric markets already has an ex-ante larger market share compared to the small rival and therefore, earns profits from the existing customer base with less incentive to offer steep discounts to new customers. Our findings helps explains why few large gas utilities with large market share are so aggressive with their poaching strategies while firms in FMCG and retail offer loyalty rewards in the face of high competition.

From a policy perspective BBPD is unlikely to raise antitrust concerns as markets become more competitive and consumers benefit from lower prices when firms have the ability to price discriminate. However, there have been instances where dominant firms have been accused of abusing their power by charging high prices to their existing customers while simultaneously encouraging rival’s customers to switch. For instance, the Swedish telecommunications company TeliaSonera was referred to competition authorities for aggressive customer poaching and forcing customer switching. Our sample of pricing experts highlight that symmetric firms are more likely to be aggressive in terms of their pricing compared to dominant firms. Therefore, existing customers might be more
disadvantaged in markets with equal sized competitors with sufficient market power compared to a single dominant firm with asymmetric market power. Since we observe that multiple firm markets are the least aggressive, encouraging entry in subscription markets might be a better policy than regulating dominant firms.

The behavior of experimental subjects also helps explain the growing investments in personalization technologies and investment in improving customer recognition. Retailers are using novel ways of collecting more granular and detailed information to target prices and promotions. Catalina, a US based marketing company that tracks billions of purchases each year has gone as far as using a shopper’s in store location to refine offers. This raises the question of how improved customer recognition impacts prices. Across all markets structures we observe that participants engage in greater price discrimination when they have additional information on customer types. Thus, firms are more likely to use additional information to personalize prices (e.g. the increase in couponing in supermarkets). However we observe that the increased price discrimination results in lower market coverage. With greater information on consumer willingness to pay some customers are priced out of the market. This suggests that customer data protection and privacy laws are necessary to ensure customer welfare is not compromised as firms invest to improve targeting capabilities.

There are certain limitations of our study. We only consider myopic customers with constant preferences, in real subscription markets the preferences of customers are volatile and they may be making long term decisions. Therefore, it would be useful to run the experimental study with real life buyers who are forward looking in their decision making and are allowed to change preferences over time. Furthermore, the current study does not allow for the possibility of endogenizing customer recognition. If firms were given the choice to invest in customer recognition technologies we expect to see different competitive dynamics.

Framed field experiments are particularly useful in comparing behavior across models of strategic interaction. This is particularly useful in the context of models of behavior based price discrimination, where theory is well developed but sensitive to modeling assumptions and the question is not whether assumptions are right or wrong, rather which features explain real world pricing strategies. We hope this study will encourage further interest in experimental validation of models pricing strategies in the presence of customer recognition.
References


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Table 1: Number of Participants

<table>
<thead>
<tr>
<th></th>
<th>Total Participants</th>
<th>Symmetric Duopoly</th>
<th>Asymmetric Duopoly</th>
<th>Multiple Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial Information</td>
<td>45</td>
<td>34</td>
<td>34</td>
<td>39</td>
</tr>
<tr>
<td>Full Information</td>
<td>44</td>
<td>28</td>
<td>32</td>
<td>31</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>89</strong></td>
<td><strong>62</strong></td>
<td><strong>66</strong></td>
<td><strong>70</strong></td>
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</table>

Table 2: Summary of Drop out

<table>
<thead>
<tr>
<th>Scenarios Completed</th>
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<th>Full Information</th>
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<tbody>
<tr>
<td>Completed 1 scenario</td>
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<td>14</td>
</tr>
<tr>
<td>Completed 2 scenario</td>
<td>10</td>
<td>12</td>
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<tr>
<td>Completed 3 scenarios</td>
<td>26</td>
<td>18</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>45</strong></td>
<td><strong>44</strong></td>
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</table>

Table 3: Average Prices Across Market Scenarios

<table>
<thead>
<tr>
<th></th>
<th>Period 1 Price</th>
<th>Price to Existing Customers</th>
<th>Price to New Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetric Duopolists</td>
<td>23.51 (4.48)</td>
<td>20.97 (7.41)</td>
<td>18.94 (8.20)</td>
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<tr>
<td>Asymmetry-Dominant</td>
<td>23.22 (4.44)</td>
<td>20.76 (5.71)</td>
<td>19.65 (5.28)</td>
</tr>
<tr>
<td>Asymmetry-Small</td>
<td>24.04 (6.47)</td>
<td>20.00 (5.60)</td>
<td>19.69 (5.37)</td>
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<tr>
<td>Multiple Firms</td>
<td>23.50 (4.89)</td>
<td>17.29 (6.83)</td>
<td>18.30 (4.15)</td>
</tr>
</tbody>
</table>

Note: Standard deviation in (parenthesis).

Table 4: Factors Influencing Observed Price Discrimination

<table>
<thead>
<tr>
<th></th>
<th>Coeff.</th>
<th>Std. Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dummy Large</td>
<td>-0.26</td>
<td>0.41</td>
</tr>
<tr>
<td>Dummy Multiple Firms</td>
<td>-0.93***</td>
<td>0.41</td>
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<tr>
<td>Dummy Information</td>
<td>0.70*</td>
<td>0.39</td>
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<tr>
<td>Constant</td>
<td>0.33</td>
<td>0.35</td>
</tr>
<tr>
<td>Participant Random Effect</td>
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<tr>
<td>$\rho$</td>
<td>0.20**</td>
<td>0.09</td>
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<tr>
<td>LL</td>
<td>-130.20</td>
<td></td>
</tr>
<tr>
<td>$\chi^2$</td>
<td>2.93 **</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>198</td>
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Note:* denotes significance at the 10% level, ** denote significance at the 5% level, *** denote significance at the 1% level.
Table 5: Comparison of Prices offered to Existing vs. New Customers-Partial Information

<table>
<thead>
<tr>
<th></th>
<th>Existing Customers</th>
<th>New Customers</th>
<th>Customer Poaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetric Duopolists</td>
<td>20.97 (7.41)</td>
<td>18.94 (8.20)</td>
<td>t=-2.58**, d.f =31</td>
</tr>
<tr>
<td>Asymmetry Duopolists</td>
<td>20.76 (5.71)</td>
<td>19.65 (5.28)</td>
<td>t=-2.33**, d.f =33</td>
</tr>
<tr>
<td>Multiple Firms</td>
<td>17.29 (6.83)</td>
<td>18.30 (4.15)</td>
<td>t=-1.15, d.f =38</td>
</tr>
</tbody>
</table>

Note: Standard errors in (parenthesis).

Table 6: Determinants of Aggressiveness

<table>
<thead>
<tr>
<th></th>
<th>Coeff.</th>
<th>Std.Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period 1 Price</td>
<td>-0.26**</td>
<td>0.13</td>
</tr>
<tr>
<td>Market Share- Low</td>
<td>-0.03***</td>
<td>0.005</td>
</tr>
<tr>
<td>Market Share- High</td>
<td>0.03***</td>
<td>0.004</td>
</tr>
<tr>
<td>Dummy Asymmetry</td>
<td>-0.63</td>
<td>1.12</td>
</tr>
<tr>
<td>Dummy Multiple Firms</td>
<td>-1.91*</td>
<td>1.22</td>
</tr>
<tr>
<td>Constant</td>
<td>7.75*</td>
<td>4.03</td>
</tr>
<tr>
<td>Participant Random Effect</td>
<td>0.51</td>
<td>2.27</td>
</tr>
<tr>
<td>LL</td>
<td>-318.98</td>
<td></td>
</tr>
<tr>
<td>$\chi^2$</td>
<td>47.16**</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>107</td>
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Note: *** denote significance at the 10% level, ** denote significance at the 5% level, *** denote significance at the 1% level.
Figure 2: Price Discrimination Across Market Structure

![Price Discrimination Across Market Structure](image)

Figure 1: Offer Prices across Markets

(a) Symmetric Duopoly

(b) Asymmetric Duopoly

(c) Multiple Firms
Figure 4: Comparison of Aggressiveness with Full Information

(a) Comparison of Aggressiveness Across Competitive Scenarios

(b) Comparison of Aggressiveness Across Size

Figure 3: Comparison of Aggressiveness with Partial Information

(a) Aggressiveness Across Competitive Scenarios

(b) Comparison of Aggressiveness Across Firm Size

Figure 5: Price Discrimination Across Information Conditions
Figure 6: Offer Prices Across Markets with Full Information

(a) Symmetric Duopoly

(b) Asymmetric Duopoly

(c) Multiple Firms
Appendix A

Symmetric Duopoly

Customer utility from purchase from A and B is defined as follows:

\[ U_A = v - tx - p^A \]

\[ U_B = v - t(1 - x) - p^B \]

We solve the equilibrium prices by backward induction. Starting the analysis in Period 2, there are two indifferent customers, customer located at \( \alpha \) who purchased from firm A in the first
period and is indifferent between switching to firm B or staying with firm A. The second indifferent
customer is located at $\beta$, purchased from firm B in the first period and is indifferent between staying
with firm B or switching to firm A. We define the indifference conditions as follows:

- Indifference condition for Firm A’s Period 1 customer

$$p_{2}^{AA} + t\alpha = p_{2}^{AB} + t(1 - \alpha)$$

-Indifference condition for Firm B’s Period 1 customer

$$p_{2}^{BA} + t\beta = p_{2}^{BB} + t(1 - \beta)$$

Based on the location of the customers second period demand is the sum of demand from
existing customers ($\alpha, (1 - \beta)$) and demand from new customers ($(\beta - x), (x - \alpha)$). Thus second
period profit of the firms can be defined as:

Firm A

$$\prod_{2}^{A} = (p_{2}^{AA} - c)\alpha + (p_{2}^{BA} - c)(\beta - x)$$

Firm B

$$\prod_{2}^{B} = (p_{2}^{BB} - c)(1 - \beta) + (p_{2}^{AB} - c)(x - \alpha)$$

Considering the interior solution optimal prices in Period 2 are as follows:

$$p_{2}^{AA} = c + \frac{t(1 + 2x)}{3}, p_{2}^{BA} = c + \frac{t(3 - 4x)}{3}, p_{2}^{AB} = c + \frac{t(4x - 1)}{3}, p_{2}^{BB} = c + \frac{t(3 - 2x)}{3}$$

The second period profits are symmetric and are defined as follows:

$$\prod_{2}^{A} = \prod_{2}^{B} = \frac{5t(2x^2 - 2x + 1)}{9}$$

We now turn to first-period competition. In the first period the myopic customers will only maxi-
mize current utility, therefore, the indifferent customer located at $x$ will face the flowing trade off
in Period 1:

$$p_{1}^{A} + tx = p_{1}^{B} + t(1 - x)$$

---

13 In Period 1 firm A’s market share is defined by $x$, while firm B’s market share is defined as $(1-x)$
However, since firms are forward looking, they will set prices in Period 1 to ensure that total profits are maximized. Therefore, the total profits will be the sum of the first period and the discounted value of the second period profits, where the discount rate $\delta < 1$.

$$\prod^A = (p^A_1 - c)x + \delta [(p^A_2 - c)\alpha + (p^{BA}_2 - c)(\beta - x)]$$

$$\prod^B = (p^B_1 - c)\alpha(1-x) + \delta[(p^{BB}_2 - c)(1 - \beta) + (p^{AB}_2 - c)(x - \alpha)]$$

Solving the necessary first order conditions in terms of $p^A_1$ and $p^B_1$ reveals a symmetric equilibrium where

$$p^A_1 = p^B_1 = c + t$$

Both firms have equal market shares in the first period i.e., $x = 0.5$.

Substituting the value of $x$ in Period 2 prices we get:

$$p^{AA}_2 = p^{BB}_2 = c + \frac{2t}{3}$$

$$p^{BA}_2 = p^{AB}_2 = c + \frac{t}{3}$$

Period 1 and Period 2 profits are symmetric

$$\prod^A_1 = \prod^B_1 = \frac{t}{2}$$

$$\prod^A_2 = \prod^B_2 = \frac{5t}{18}$$

Asymmetric Duopoly

Customer utility along the competitive segment is defined as follows:

$$U^A = v - t x' - p^A$$

$$U^B = v - t(1 - x') - p^B$$
While utility of the loyal customers is defined as

\[ U_A = v - tx - p^A \]

Starting in Period 2 we solve the model by backwards induction and only consider interior solutions where both firms remain in the market. Similar to the symmetric market the indifferent switching customers will be located in the \(1 - l\), segment of the market. Firm A’s existing customers indifferent between switching to firm B will be located at \(\alpha'\), while firm B’s existing customers indifferent between switching to firm A will be located at \(\beta'\).

- Indifference condition for Firm A’s customer

\[ p_2^{AA} + t\alpha' = p_2^{AB} + t(1 - \alpha') \]

- Indifference condition for Firm B’s customer

\[ p_2^{BA} + t\beta' = p_2^{BB} + t(1 - \beta') \]

Based on the location of the customers second period demand is the sum of demand from existing customers (\(\alpha, (1 - \beta)\)) and demand from new customers ((\(\beta - x\), \(x - \alpha\)), where \(x\) is the Period 1 market share of the dominant firm A in the competitive segment. Thus second period profit of the firms can be defined as:

**Firm A**

\[ \prod_2^A = (p_2^{AA} - c)(1 + \alpha') + (p_2^{BA} - c)(\beta' - x') \]

**Firm B**

\[ \prod_2^B = (p_2^{BB} - c)(1 - \beta') + (p_2^{AB} - c)(x' - \alpha') \]

Solving the F.O.C.s with respect to Period 2 prices we get the following interior solution for Period 2 prices.

\[ p_2^{AA} = c + \frac{t(2x' + 4l + 1)}{3}, p_2^{BA} = c + \frac{t(3 - 4x')}{3}, p_2^{AB} = c + \frac{t(4x' + 2l - 1)}{3}, p_2^{BB} = c + \frac{t(3 - 2x')}{3} \]

We now turn to first-period competition. Myopic first-period indifferent consumers only consider the current period prices offered by the two firms. The indifferent customer located at \(x'\) faces the following trade off:
\[ p_1^A + tx = p_1^B + t(1-x') \]

Forward looking firms will maximize total profits given the discount rate \( \delta \).

\[
\begin{align*}
\Pi^A &= (p_1^A - c)(l + x') + \delta[(p_2^{AA} - c)(l + \alpha') + (p_2^{BA} - c)(\beta' - x')] \\
\Pi^B &= (p_1^B - c)t(1-x') + \delta[(p_2^{BB} - c)(1 - \beta') + (p_2^{AB} - c)(x' - \alpha')] 
\end{align*}
\]

Solving for Period 1 prices results in the following:

\[
\begin{align*}
p_1^A &= t + \frac{t(4l(81 - 99\delta - 40\delta^2))}{9(27 - 20\delta)} + c \\
p_1^B &= t + \frac{t(2l(81 - 198\delta - 80\delta^2))}{9(27 - 20\delta)} + c
\end{align*}
\]

The competitive segment market share for the dominate firm can be defined as:

\[
x' = \frac{t}{2t} - \frac{9l}{(27 - 20\delta)}
\]

Substituting the value of \( x \) we get the following Period 2 prices:

\[
\begin{align*}
p_2^{AA} &= c + \frac{2t}{3} + \frac{2lt(45 - 40\delta)}{81 - 60\delta} > p_2^{AA} \\
p_2^{BB} &= c + \frac{2t}{3} + \frac{18lt}{81 - 60\delta} > p_2^{BB} \\
p_2^{BA} &= c + \frac{t}{3} + \frac{36lt}{81 - 60\delta} > p_2^{BA}
\end{align*}
\]
\[ p_{2}^{AB} = c + \frac{t}{3} + \frac{2lt(9 - 20\delta)}{81 - 60\delta} > p_{2}^{AB} \]

The resultant market share in the competitive segment for the dominant firm is:

\[ \alpha + \beta - x' = \frac{1}{2} - \frac{l(18 - 20\delta)}{3(27 - 20\delta)} \]

Period 1, profit for the two firms is:

\[
\Pi_A^1 = \left[ t + \frac{t(4l(81 - 99\delta - 40\delta^2))}{9(27 - 20\delta)} \right] \left[ \frac{1}{2} - \frac{9l}{(27 - 20\delta)} + t \right]
\]

\[
\Pi_B^1 = \left[ t + \frac{t(2l(81 - 198\delta - 80\delta^2))}{9(27 - 20\delta)} \right] \left[ \frac{1}{2} + \frac{9l}{(27 - 20\delta)} \right]
\]

**Four Firms**

In this section we analyze the equilibrium prices for a market with multiple equal sized firms. The indifferent existing customer for firm B is located at

\[ p_{2}^{Bexist} + t\alpha_2 = p_{2}^{Cnew} + t\left( \frac{1}{4} - \alpha_2 \right) \]

\[ \alpha'' = \alpha_1 + \alpha_2 = \frac{p_{2}^{Anew} - p_{2}^{Bexist}}{2t} + \frac{p_{2}^{Cnew} - p_{2}^{Bexist}}{2t} + \frac{1}{4} \]

\[ p_{2}^{Bnew} + t\left( \frac{1}{4} - \beta_1 \right) = p_{2}^{Aexist} + t\beta_1 \]

\[ p_{2}^{Bnew} + t\left( \frac{1}{4} - \beta_2 \right) = p_{2}^{Cexist} + t\beta_2 \]

\[ \beta'' = \beta_1 + \beta_2 = \frac{p_{2}^{Bnew} - p_{2}^{Aexist}}{2t} + \frac{p_{2}^{Bnew} - p_{2}^{Cexist}}{2t} + \frac{1}{4} \]
Imposing a symmetric equilibrium, all firms offer the same price to new and existing customers

\[ p_{A_{new}}^{new} = p_{B_{new}}^{new} = p_{C_{new}}^{new} = p_{D_{new}}^{new} \]

\[ p_{A_{exist}}^{exist} = p_{B_{exist}}^{exist} = p_{C_{exist}}^{exist} = p_{D_{exist}}^{exist} \]

\[ \prod = (p_{2}^{exist} - c)\alpha + (p_{2}^{new} - c)(\beta - x) \]

\[ p_{2}^{exist} = c + \frac{t}{4} - \frac{2tx''}{3}, \quad p_{2}^{new} = c + \frac{t}{4} - \frac{4tx''}{3} \]

Price offered to new customers is lower than the price to existing customers.

Indifferent customer for firm B in Period 1 N

\[ p_{1}^{B} + tx_{A}^{''} = p_{1}^{A} + t\left(\frac{1}{4} - x_{A}^{''}\right) \]

\[ p_{1}^{B} + tx_{B}^{''} = p_{1}^{C} + t\left(\frac{1}{4} - x_{B}^{''}\right) \]

\[ x_{1}^{''} = x_{A}^{''} + x_{B}^{''} = \frac{(p_{1}^{A} - p_{1}^{B}) + (p_{1}^{C} - p_{1}^{B})}{2t} + \frac{1}{4} \]

\[ \prod_{B}^{''} = x_{1}^{''}(p_{1}^{B} - c) + \delta[p_{2}^{BB}^{''}\alpha^{''} + p_{2}^{B_{new}}^{''}] \]

Maximize subject to prices.

\[ p_{1}^{A} = p_{1}^{B} = p_{1}^{C} = p_{1}^{D} = c + \frac{t}{4} \]

\[ \text{14} \text{Despite the dynamic game, the first period equilibrium is similar to the equilibrium in a static one period model without BBPD.} \]
\[
\prod_{i=1}^{t} = \frac{t}{16}
\]

All firms equally share the market in Period 1, which implies that \( x = 0.25 \).

Appendix B

Instructions

Week 1: Introductory E-mail

Thank you for participating in our experiment. In this experiment you will be participating in a series of price setting scenarios. You are the pricing and promotion expert for Astra supermarket; located in town X. Astra deals in a wide range of products, including groceries, electronics, apparel, insurance and financial services.

Every week you will be making pricing and promotion decisions for Astra under different scenarios. You will be making important pricing and promotion decisions, which will impact the profitability of your store and in turn your earnings. Your pay is directly proportional to the profit earned by your firm.

The price-setting task will be straightforward and will only take 5-10 minutes or longer depending on how long it takes you to arrive at a decision. You will have a 24-hour window to submit your decision. After you set the prices, details of your earning and performance will be provided through email once all other participants have made their decisions.

The first week is the trial week to familiarize you with the procedure. The actual experimental sessions will commence the following week.

Each week your earnings from the experiment will be recorded. At the end of the experiment 2 random participants will be selected to receive a payment based on their performance in the price setting experiment. We expect selected participants to earn around £200 at the end of the experiment.

Week 2: Scenarios

Symmetry

Astra’s main competitor is Beta mart, which has a product selection identical to Astra. In addition, the same wholesaler supplies to both supermarkets and charges identical wholesale prices to both supermarkets.
Due to town planning regulations, stores can only locate on the outskirts of the city. • Astra is located at the west end of the town while Beta mart is located on the east end.
  • The distance between the two stores is 20 miles
  • You will be setting the prices across 2 periods. You must decide on the optimal price and promotion for each product category taking into account costs and competitor strategy.

Figure 9: Symmetric Competition

Asymmetry

You are in charge of the pricing and promotion of Giant (Townsend) supermarket, located in Town X. There is one other competing supermarket Townsend (Giant) supermarket, in Town X. Townsend (Giant) is a relatively small (large) store compared to Giant (Townsend) supermarket. Despite its small size, Townsend has a product selection, which is identical to Giant supermarket. In addition, the wholesaler supplying Giant supermarket and Townsend is the same and due to government regulation charges the same wholesale prices.
  • Due to its large size, Giant is located in the center of the town while Townsend is located on the east end
  • The distance between the two stores is 10 miles
  • Giant is conveniently located for 2/3rd of the customers while the remaining 1/3rd find Townsend is closer

Figure 10: Asymmetric Market
Four Firms

You are in charge of the pricing and promotion of A mart, located in Town X. There are 3 other supermarkets; B, C and D, in Town X. All 4 supermarkets have identical product selection. The wholesaler supplying the supermarkets is the same and due to government regulation charges the same wholesale prices.

• All stores are 5 miles apart
• Each supermarket is conveniently located for 1/4th of the town’s population
• You will be setting price across 2 periods. You must decide on the optimal price and promotion for each product category taking into account costs and competitors strategy.

Period 2/ Next Day Email

Welcome to period 2 of the experiment Welcome to period 2 of the experiment.

Customers in have now made purchases for electronic brush heads. Following is the detail of the market sales:

— Customers bought from you @ a price of £——
— Customers bought from your competitor: Townsend Mart @ a price of £——

Your market share in period 1 was: ——
Your total profit is £———

The sales department has compiled a database of the customers who purchased from you. In addition you have purchased detailed customer data from a market research firm. The detailed market analysis enables you to distinguish between customers based on their purchase behavior.

Based on this information you learn that customers in the market vary in their valuation for the product you sell. The market research firm identifies 3 distinct customer segments:

Existing customer with a low willingness to pay:
— Low-type customers purchased from Giant supermarket in the period 1. Purchase behavior in conjunction with survey data shows that these are low-type customers who will not be willing to pay more than £25 for brush heads
Existing customer with a high willingness to pay:
—— High-type customers purchased from Giant supermarket in the period 1. Purchase behavior in conjunction with survey data shows that are high-type customers who will not be willing to pay more than £50 for brush heads.

New customers:
——- Customers did not purchase from Giant supermarket. Due to data privacy you cannot access willingness to pay information for these customers. This segment comprises of the remaining high and low type customers that did not purchase from you in period 1.

Additionally, the survey data on store preferences suggests that while customers have a liking for a particular store they could consider switching if they find the product at a suitable price.

In period 2 you again need to set prices in order to maximize sales in light of your performance in the previous period. One option is to offer different prices to different customer segments.

You can send personalized discount coupons to customers, would you choose to offer different prices to the different customer segments?

a) Yes b) No

What is the price (including any discount) you will set to Existing customer with a low willingness to pay?

What is the price (including any discount) you will set to Existing customer with a high willingness to pay?