The Charm of Behavior-based Pricing:

Effects of Product Valuation, Reference Dependence, and Switching Cost

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Abstract

Technology is making it easier for firms to track consumers' purchase history and leverage the information in setting prices. The extant literature on behavior-based pricing (BBP), however, casts doubt on the value of consumers' purchase history. It shows that BBP hurts firms' profits under general conditions. Yet, in practice, we see firms widely using BBP. Moreover, in many product categories, consumers' tastes are diverse and they seek a variety of products. This paper explores the practice of BBP in a horizontally differentiated market where consumers' tastes are diverse. Contrary to prior literature, our analysis shows that when consumer valuation is low, BBP can improve firms' profits. Prior literature on BBP has neglected the empirical evidence that consumers care about not only the consumption utility derived from a product but also the gain-loss utility in comparison to the reference product. We find that when consumers are sufficiently averse to loss on match quality, firms benefit from adopting BBP if consumer valuation is high. However, loss aversion on price does not affect the profitability of BBP. This result is robust to how consumers form the reference price – whether they anchor on the current period price or on the historical price of the reference product. We also clarify that neither switching cost nor announcing the introductory price and regular price can eliminate the peril of BBP.

Keywords: Behavior-based Pricing, Reference-Dependent Utility, Game Theory, Spokes Model.

1. INTRODUCTION

With the advent of new technologies the use of behavior-based pricing is becoming more common. Cable and satellite television companies, as well as internet service providers, routinely make attractive offers to new consumers, only to raise their prices substantially after the introductory period (see Exhibit 1 on page 39). Uber, Lyft, and Airbnb offer sign-up incentives for new users, and credit card companies often offer zero or low interest rates to consumers who open new accounts, but not for current consumers. Several research papers, however, show that behavior-based pricing (BBP) hurts firms' profits (e.g., Chen, 1997; Villas-Boas, 2004; Acquisti and Varian, 2005; Zhang, 2011). We observe this theoretical result because firms practicing BBP compete intensely for new consumers and lose the benefit accruing from the ability to charge a higher price for old consumers.

An important assumption in prior literature is that consumer valuation of products is high (Fudenberg and Villas-Boas, 2006; Zhang, 2011; Shin and Sudhir, 2010). In reality, however, consumers buy a variety of low-valuation services, such as ride-sharing and cleaning services, and low-valuation products, such as razors and shaving cream. Moreover, because of the ability to closely track consumers, online service firms and retailers price discriminate between old and new consumers. This observation raises the practical question whether BBP can be profitable for low-valuation goods. Next, prior research on BBP has primarily focused attention on markets composed of two products, with both being considered by all consumers (e.g., Fudenberg and Villas-Boas, 2006; Zhang, 2011). In several product categories, however, consumers' tastes are diverse. For example, consumers seek a variety of benefits from credits cards, such as low interest rate, balance transfer, cash back, international use, low late payment penalty, and affiliation with airline/hotel. Likewise, viewers seek a variety of programs, such as comedy, news, sports, international programs and travel. In product categories where consumers' tastes are very diverse, not all the variety that a consumer seeks may be available, and thus markets may not be fully covered. For example, some consumers may not be able to get a card affiliated with their preferred hotel chain or watch an international program in their native language. This observation poses the interesting question of whether the perils of BBP will extend to markets where consumers' tastes are diverse. Another common assumption in prior literature is that firms use consumers' purchase history to offer customized prices for new and old consumers, but consumers' purchase decisions are not tempered by their knowledge of past purchases (Acquisti and Varian, 2005; Shin and Sudhir, 2010). Yet there is an extensive literature in marketing, economics, and psychology showing that consumers anchor their purchase decisions on past purchases (e.g., Hardie, Johnson, and Fader, 1993; Meyer and Johnson, 1995; Kalyanaram and Winer, 1995; Neumann and Böckenholt, 2014). Moreover, consumers not only care about the intrinsic utility derived from consuming a product but also about the gain-loss utility in comparison to the reference product (Tversky and Kahneman, 1991; Kőszegi and Rabin, 2006). This phenomenon raises yet another research question: Can reference dependence on the part of consumers affect the profitability of behavior-based pricing? Some may view the idea of reference dependence as a form of stickiness with past choice and wonder whether switching cost can induce a similar effect on BBP. Finally, we see some internet service providers, such as Comcast and Spectrum, and credit card companies, such as Citicards, announcing both the introductory price and the regular price to consumers. The practice of committing to the price the firm would charge after the introductory period poses the question whether such an announcement will improve the profitability of BBP and remove the peril of BBP. Thus many issues pertaining to BBP await further scrutiny.

To theoretically examine these issues, we first propose an analytical model that incorporates the notion of behavior-based pricing in the spokes model. The spokes model is a parsimonious framework that allows us to investigate a market where consumers' tastes are diverse and all the products that they seek need not be available. Our analysis of the model shows that in product categories where consumer valuation is relatively low, competing firms can earn more profits with BBP than without it. The intuition is that when consumers' tastes are diverse, the first-preferred product of some consumers may not be available. Furthermore, when consumer valuation is low, some of these consumers are priced out of the market in the initial period. However, if firms adopt BBP and offer a low poaching price in the second period, some of the unserved consumers become a source of new demand. The resulting market expansion facilitated by BBP can outweigh the effect of competition induced by BBP, thus making BBP profitable.

Second, we enrich our model with the idea of reference-dependent utility, where consumers use the previously purchased product as the reference product. The BBP literature assumes that firms can leverage the purchase history of consumers to offer customized prices. As evidenced in the literature on reference dependence, consumers can also use information about their past purchase while making product choices. When consumers use the last purchased product as the reference product, they incur a psychological loss due to mismatch on taste if they purchase a new product. They can incur an additional loss if the price of the nonreference product is higher than that of the reference product. Our analysis shows that if consumers' loss aversion on match quality is sufficiently high, then firms earn more profits with BBP than without BBP. This is because loss aversion on match quality makes consumers more sensitive to product differentiation and softens the competition in the second period. However, loss aversion on price does not affect the profitability of BBP because the reference product is sold at a higher price than the new product.

Third, we consider a model of switching cost and examine its effect on the profitability of BBP. On analyzing the model, we find that if the switching cost is sufficiently high, firms earn lower profits with BBP than without it. This occurs because when consumers face a switching cost, firms need to further reduce the price for new consumers to encourage them to switch. Thus, unlike reference-dependent utility, switching cost aggravates the perils of BBP. Fourth, we consider a model where firms announce the introductory price and the regular price. We find that such an announcement increases the profitability of BBP, but firms still earn more profits without BBP than with it.

Finally, we extend the model in a few directions to assess the robustness of our findings. In our original model, consumers use a cross-sectional reference price. In an extension, we consider an alternative formulation of reference dependence where consumers compare their current options against the historical price and the match quality of the last purchased product. Our analysis shows that BBP remains profitable when consumers use the historical price of the reference product as the reference price. To understand the underlying rationale, note that BBP typically hurts competing firms' profits. However, when consumer utility is reference dependent, the second-period price competition is muted. Furthermore, if consumers' reference price is the first-period price of the reference product, forward-looking firms will raise their prices in the first period to mitigate consumers' loss aversion on price in the second period. Thus, the historical reference price helps firms to earn more profits with BBP than without it. In keeping with prior literature on the spokes model, our original model assumes that consumers consider at most two products. Next, we extend the model to let the consideration set size be more than two, and show that our original results can be recovered in this extension.

Related Literature. Our work is related to the literature on behavior-based pricing (see Fudenberg and Villas-Boas, 2006, for a recent review). Villas-Boas (2004) shows that a monopolist is worse off when it charges different prices to past consumers and new consumers compared with when it charges a uniform price for all consumers. Acquisti and Varian (2005) examine a market with forward-looking consumers who have either high or low valuation for the goods sold by a monopolist. They show that a monopolist never finds it optimal to engage in targeted pricing when the firm can commit to a pricing policy. The negative effect of BBP can extend to a duopoly market. Using a two-period homogeneous-good duopoly model, Chen (1997) shows that behavior-based pricing reduces duopolists' profits. Zhang (2011) notes that BBP reduces competing firms' profits not only through intensified competition but also by inducing them to offer less differentiated products. Some researchers have identified certain conditions under which BBP can improve firms' profits in a duopoly model. Using a two-period differentiated-goods model, Chen and Zhang (2009) show that in a mixed strategy equilibrium, competing firms can benefit from BBP if some loyal consumers strategically withhold their purchase in the first period. Our formulation is different from Chen and Zhang (2009). In our model, all consumers are price elastic, and we have a continuous demand function instead of a discrete one.[1] Furthermore, all consumers purchase in both periods in our model. Shin and Sudhir (2010) find that when consumers are heterogeneous in their purchase quantities and their preferences (locations) are stochastic across periods, a duopolist can benefit from targeted pricing in the second period. Our analysis offers a rationale for why BBP can be profitable for competing firms even when consumers make a unit purchase in each period and their preferences are stable across the two periods. Moreover, our research clarifies how consumer valuation, diversity in consumers' tastes,

[1] In a mixed strategy model, some consumers (loyal consumers) are completely price inelastic whereas other consumers (switchers) are infinitely price elastic.

reference-dependent utility, switching cost, and price announcement impact the profitability of behavior-based pricing.

In a BBP model, because new consumers pay a lower price than old consumers, peer-induced fairness can make the old consumers unhappy about their higher price, and this may motivate them to consider buying the competing product. Li and Jain (2016) show that if consumers are sufficiently concerned about price fairness, BBP can be beneficial for duopolists. Note that in a model of peer-induced fairness, consumers experience a psychological disutility based on the price difference without regard to the match qualities of the competing product. In our model of reference-dependent utility, consumers factor in both the difference in price as well as the difference in match quality and are averse to loss on both dimensions. Moreover, in a model of reference-dependent utility, as the reference product is priced higher than a nonreference product, loss aversion on match quality (not price) plays a critical role. Thus reference dependence and price fairness influence BBP through different psychological mechanisms. Further leveraging our spokes model, we show that if consumer valuation is low, BBP can be profitable even in the absence of factors such as fairness and reference-dependent utility. Our formulation also permits one to examine how diversity in consumers' tastes can affect the profitability of BBP. We also clarify that a firm cannot avoid the peril of BBP by announcing simultaneously the introductory price and regular price. Thus, our goal, model formulation, and findings are different from Li and Jain (2015).

Our work adds to prior research on reference-dependent utility. Kőszegi and Rabin (2006) show that a consumer's willingness to pay for a product depends on the probability with which she expected to buy the product and on the price she expected to pay. An increase in the expected probability of buying a product raises a consumer's sense of loss if she does not buy, and this increases her willingness to pay for the product. Hence, if a consumer expected a low enough price to motivate her to purchase a product, her willingness to buy the product at a higher price increases. However, when the probability of getting the product is held constant, a decrease in expected price makes paying a higher price to be viewed as loss, and it reduces her willingness to pay a high price. As Kőszegi and Rabin (2006, *p.*1141) note, this model makes the strong assumption that the reference point is fully determined by the expectations a person held in the recent past. Using a similar model of reference-dependent utility, Kőszegi and Rabin (2007) show that loss aversion causes first-order risk aversion toward all insurable risks. This is because the bad outcome of an uncertain lottery is viewed as a loss while a fully expected premium is not considered a loss. However, *à priori* expectation to take on risk reduces aversion to anticipated and additional risk. In our model there is no uncertainty. Furthermore, as in Tversky and Kahneman (1991) and Hardie Fader Johnson (1993), we assume that the reference product is determined by consumers' purchase history. In particular, consumers treat the product purchased in the previous period as the reference product. When comparing a potential purchase option with the reference product, consumers could anchor on the current price of the reference product or the past price of the reference product. We explore the strategic implications of both types of reference prices.

An emerging body of research investigates the supply-side implications of reference dependent utility. In a model where firms' costs are stochastic, Heidhues and Kőszegi (2008) show that competing firms may charge the same price even if their actual costs are not the same. This is because if a firm charges a price that is above the expected price, consumers perceive buying the product at that price as a loss in money, and it hurts the firm's profits. Charging a lower than expected price is not very helpful because the demand is less responsive to a price cut. Hence, it is profitable for competing firms to adopt a focal-price equilibrium when the cost asymmetry is not too high. We also consider a horizontally-differentiated market, but there is no uncertainty or cost asymmetry in our model. Moreover, in equilibrium firms do not charge a single price in the second period but choose to price discriminate between new and old consumers.

Our research is related to Zhou's (2011) work on the implications of reference-dependent utility for a duopoly. In his model, all consumers consider both of the products in the market, implying that the consideration set and the universal set are the same. Unlike Zhou (2011), in our framework the notions of consideration set and products available in the market are conceptually distinct. Furthermore, Zhou examines competing firms' pricing strategy in a static setting and obtains a mixed-strategy solution. In contrast, we use a dynamic model and examine the pure-strategy equilibrium to understand the strategic implications of reference-dependent utility for the practice of BBP.

In a recent paper using a single-period model, Amaldoss and He (2017) explore how reference-dependent utility impacts firms' pricing strategies in a market where consumers' tastes are diverse. Our model, objective, and analysis differ from Amaldoss and He (2017) in several important ways. First, we use a dynamic model to understand how reference-dependent utility affects consumers' forward-looking behavior and, in turn, the profitability of BBP. Second, we consider some finer nuances on how consumers form reference prices. In particular, consumers could use the current period price or the historical price of the reference product as the anchor while making a purchase decision. Third, we investigate how switching cost and price announcements affect the profitability of BBP.

The rest of the paper is organized as follows. Section 2 introduces a model of BBP grounded in the spokes framework and examines its implications. Section 3 presents a formulation of reference-dependent utility and explores its implications for BBP. Section 4 examines the effect of switching cost on BBP. Section 5 investigates how the profitability of BBP is affected by announcing the introductory price and the regular price in the first period. Section 6 extends the model in a few directions to assess the robustness of our results. Finally, Section 7 concludes the paper and outlines avenues for further research.

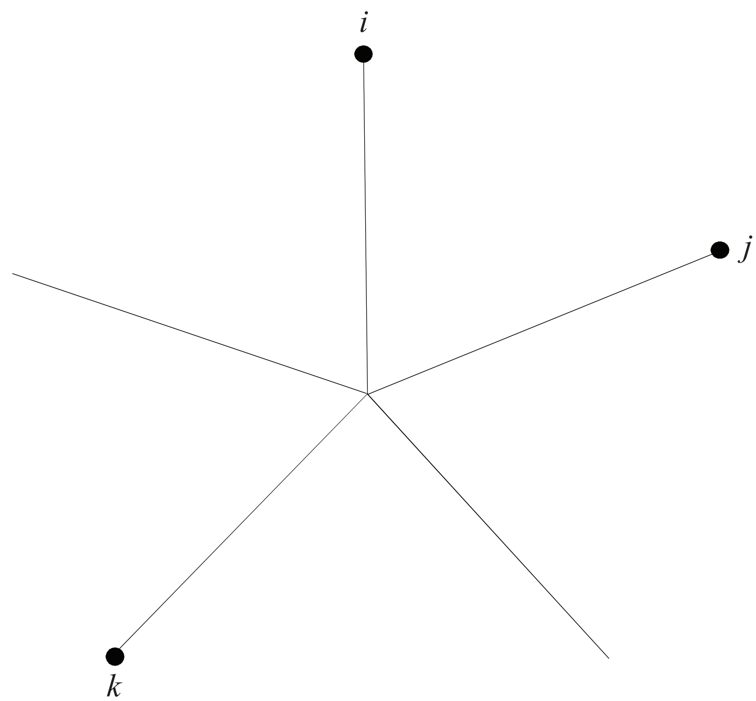
2. A MODEL OF BEHAVIOR-BASED PRICING

In this section, we introduce the spokes model, incorporate the idea of behavior-based pricing in the model, and then examine its implications. For detailed discussion on the advantages of using the spokes model, readers are referred to Chen and Riordan (2007) and Amaldoss and He (2010).

Spokes Model. Consider a product category where consumers have diverse taste and seek N varieties in the category. Let each of the n firms competing in the market offer one variety, where $2 \leq n \leq N$. We model this market as a spokes network on a plane (Chen and Riordan, 2007; Amaldoss and He, 2010, 2013). Each firm indexed $j \in \{1, \ldots, n\}$ is situated at the end of the spoke for that variety. The base value that consumers derive from a product is v. Figure 1 illustrates a market where consumers seek $N = 5$ varieties, but only $n = 3$ products are available.

A unit mass of consumers is uniformly distributed on the spokes. Consumers preferring variety j ($j = 1, 2, \ldots N$) are distributed on spoke l_j of length $\frac{1}{2}$. Let (l_j, x) denote the

FIG. 1. An illustration of the spokes model with $N = 5$ and $n = 3$



consumer on spoke j at distance x from the end of the spoke where $x \in \left[0, \frac{1}{2}\right]$. If the consumer buys the local product j, she will derive the (indirect) utility $v - tx - p_j$, where t is her sensitivity to product characteristics and p_j is the price of the product. On the other hand, if the consumer were to buy another product k, she needs to travel a distance of $(1 - x)$ because the consumer is $\frac{1}{2} - x$ units away from the center of the spokes network and the nonlocal product is an additional $\frac{1}{2}$ unit away, that is $\frac{1}{2} - x + \frac{1}{2} = 1 - x$. Thus, the (indirect) utility derived from the nonlocal product k will be $v - t(1-x) - p_k$. The marginal consumer who is indifferent between the two products is at distance $\frac{1}{2} + \frac{p_k - p_j}{2t}$ from product j.

Prior literature suggests that consumers typically choose from a small consideration set when making a purchase decision (Nedungadi, 1990; Hauser and Wernerfelt, 1990). In keeping with this literature, the spokes model assumes that consumers consider at most two products (Chen and Riordan, 2007; Amaldoss and He, 2010, 2013). In our model, the first-preferred product of a consumer is the local variety corresponding to the spoke in which she resides. The second-preferred product is one of the nonlocal varieties, and it is exogenously fixed *à priori*. Note that sometimes a product featuring in a consumer's consideration set may not be available as there are only n single-product firms in the market whereas consumers seek $N \geq n$ varieties. Next we incorporate the notion of behavior-based pricing in the spokes model.

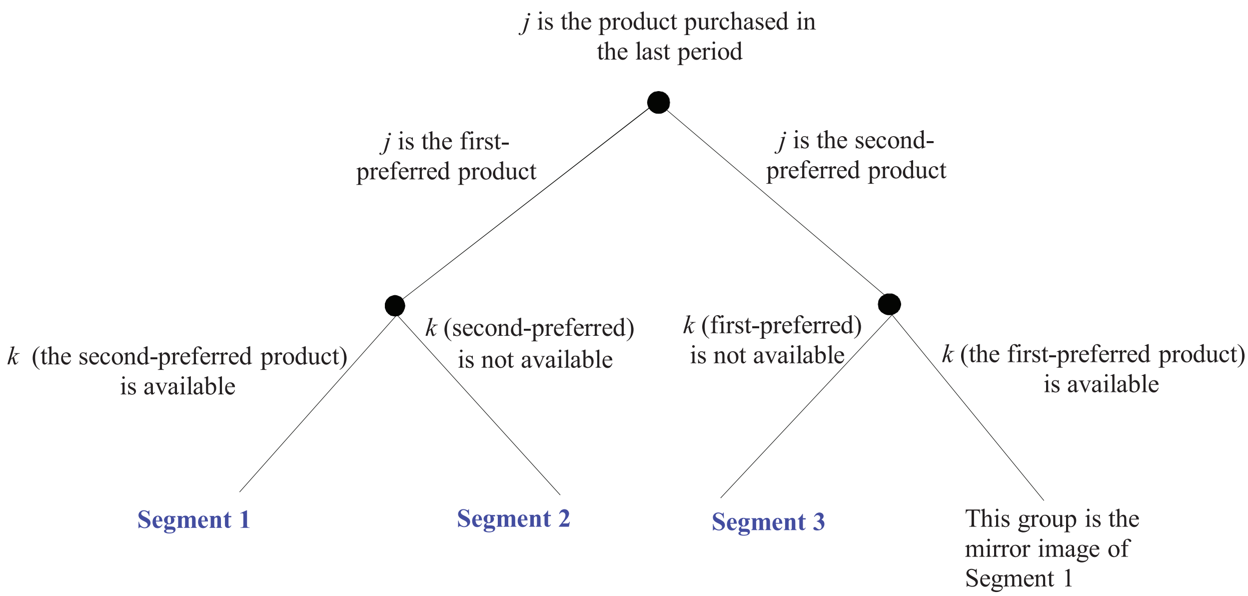
Behavior-Based Pricing. Consider a two-period market, where consumers buy one unit of a product in each period. In the first period, when firms set prices they do not know the preferences of consumers, and hence charge a single price for all consumers. In the second period, however, firms can distinguish their old consumers from new consumers, and hence they charge two prices: a price for old consumers and another price for new consumers. We examine the subgame perfect equilibrium of the game to understand the strategic behavior of competing firms. As we use backward induction to solve the game, we discuss next the second period and then the first period of the game.

Period 2. In the second period, firm j draws its demand from old consumers as well as new consumers. Let firms j and k charge their old consumers p_{j2o} and p_{k2o}, respectively. Furthermore, let them charge their new consumers p_{j2n} and p_{k2n}, respectively. Below we first outline the demand for product j (offered by firm j) from old consumers and then the corresponding demand from new consumers.

Old Consumers. The demand from old consumers emanates from three segments of consumers. The first segment includes consumers whose first-preferred product and second-preferred product are both available. The second segment is comprised of consumers whose first-preferred product is product j, but the second-preferred product is not available. The third segment is made up of consumers whose first-preferred product is not available and the second-preferred product is product j. Figure 2 illustrates how the old consumers can be partitioned into these three segments.

Segment 1. Consumers in this segment decide on whether to buy the first-preferred product j or the second-preferred product k in their consideration set, depending on the relative prices of the two products: p_{j2o} and p_{k2n}. Notice that for any consumer located on l_j, product k is her second-preferred product with probability $\frac{1}{N-1}$, where $k \in \{1, \ldots, n\}$ and $k \neq j$. The density of such consumers is $\frac{2}{N}$ because consumers are evenly distributed on all spokes. Let θ_1 be the location of the marginal consumer who purchased product j in the first period.

Fig. 2. Segmentation of the old consumers



Note that the segment size of consumers who repeat purchase product j in the second period cannot exceed θ_1. Hence, the demand for product j from this segment of old consumers is as follows:

$$\frac{2}{N}\frac{1}{N-1}\sum_{k\neq j,k\in\{1,\ldots,n\}}\min\left\{\max\left\{\frac{1}{2}+\frac{p_{k2n}-p_{j2o}}{2t},0\right\},\theta_1\right\}. \tag{1}$$

Segment 2. Because the second-preferred product of consumers in this segment is not available, they need to decide whether to repeat buy product j or nothing. For any consumer on spoke l_j, her second-preferred product is not available with conditional probability $\frac{N-n}{N-1}$. Thus, the demand for product j from this segment of old consumers is given by:

$$\frac{2}{N}\frac{N-n}{N-1}\min\left\{\max\left\{0,\frac{v-p_{j2o}}{t}\right\},\frac{1}{2}\right\}. \tag{2}$$

Segment 3. Consumers in this segment consider product j to be their second-preferred product and their first-preferred product is not available. We know that for a consumer on spoke l_h, $h\notin\{1,\ldots,n\}$, product j is the second-preferred product with probability $\frac{1}{N-1}$. Moreover, the density of such consumers is $\frac{2}{N}(N-n)$, and the demand for product j from these consumers is:

$$\frac{2}{N}\frac{N-n}{N-1}\min\left\{\max\left\{0,\frac{v-p_{j2o}}{t}-\frac{1}{2}\right\},\frac{1}{2}\right\}. \tag{3}$$

Upon aggregating the demand from the three segments, we have the following total demand for product j from old consumers (people who purchased product j in period 1):

$$q_j = \begin{cases} \frac{2}{N}\frac{1}{N-1}\sum\limits_{k\neq j,k\in\{1,\dots,n\}}\min\left\{\max\left\{\frac{1}{2}+\frac{p_{k2n}-p_{j2o}}{2t},0\right\},\theta_1\right\} & \\ +\frac{1}{N}\frac{N-n}{N-1}+\frac{2}{N}\frac{N-n}{N-1}\left(\frac{v-p_{j2o}}{t}-\frac{1}{2}\right), & \text{for} \quad \frac{1}{2}<\frac{v-p_j}{t}<1 \\ \frac{2}{N}\frac{1}{N-1}\sum\limits_{k\neq j,k\in\{1,\dots,n\}}\min\left\{\max\left\{\frac{1}{2}+\frac{p_{k2n}-p_{j2o}}{2t},0\right\},\theta_1\right\} & \\ +\frac{2}{N}\frac{N-n}{N-1}, & \text{for} \quad \frac{v-p_j}{t}\geq 1. \end{cases} \tag{4}$$

New Consumers. Next we discuss the demand for product j from new consumers in each of the three segments outlined above.

Segment 1. Recall that consumers in this segment could buy either of the products in their consideration set in the first period. The source of new demand for product j in the second period comes from consumers who switch from product k (in the first period) to product j (in the second period). The corresponding demand is given by:

$$\frac{2}{N}\frac{1}{N-1}\sum_{k\neq j,k\in\{1,\dots,n\}}\min\left\{\max\left\{\frac{1}{2}+\frac{p_{k2o}-p_{j2n}}{2t}-\theta_1,0\right\},\theta_1\right\}. \tag{5}$$

Segment 2. Recall that product j is the first preferred product for consumers in this segment, and their second-preferred product is not available. Because all the consumers in this segment are old, we do not have new consumers for product j in the second period.

Segment 3. Product j is the second-preferred product of consumers in this segment, and their first-preferred product is not available. Some consumers in this segment who did not buy product j in the first period could buy the product in the second period. Specifically, if consumer valuation is below a threshold and the poaching price in the second period is below the first-period price, then some consumers may be able to purchase product j at the poaching price p_{j2n}.

When the second-period price for new consumers is lower, the marginal consumer who did not buy product j in the first period but is open to buying the product in the second period is given by $\frac{v-p_{j2n}}{t}$. Let θ_2 denote the location of the marginal consumer in this monopoly segment who purchased product j in the first period. Then the segment of new consumers who can buy product j in the second period is given by $\frac{v-p_{j2n}}{t} - \theta_2$.

In sum, the new demand for product j in the second period is given by:

$$\widehat{q}_j = \begin{cases} \frac{2}{N}\frac{1}{N-1} \sum\limits_{k\neq j, k\in\{1,\ldots,n\}} \min\left\{\max\left\{\frac{1}{2} + \frac{p_{k2o}-p_{j2n}}{2t} - \theta_1, 0\right\}, \theta_1\right\} & \text{for } \frac{1}{2} < \frac{v-p_j}{t} < 1 \\ +\frac{2}{N}\frac{N-n}{N-1}\max\left\{\frac{v-p_{j2n}}{t} - \theta_2, 0\right\}, & \\ \frac{2}{N}\frac{1}{N-1} \sum\limits_{k\neq j, k\in\{1,\ldots,n\}} \min\left\{\max\left\{\frac{1}{2} + \frac{p_{k2o}-p_{j2n}}{2t} - \theta_1, 0\right\}, \theta_1\right\}, & \text{for } \frac{v-p_j}{t} \geq 1; \end{cases} \tag{6}$$

which can be simplified to:

$$\widehat{q}_j = \begin{cases} \frac{2}{N}\frac{n-1}{N-1}\left(\frac{1}{2} + \frac{p_{k2o}-p_{j2n}}{2t} - \theta_1\right) + \frac{2}{N}\frac{N-n}{N-1}\left(\frac{v-p_{j2n}}{t} - \theta_2\right), & \text{for } \frac{1}{2} < \frac{v-p_j}{t} < 1 \\ \frac{2}{N}\frac{n-1}{N-1}\left(\frac{1}{2} + \frac{p_{k2o}-p_{j2n}}{2t} - \theta_1\right), & \text{for } \frac{v-p_j}{t} \geq 1 \end{cases} \tag{7}$$

In period 2, firm j chooses its optimal prices for old and new consumers (p_{j2o}, p_{j2n}) with the goal of maximizing its second period-profits. On solving for the symmetric pure strategy equilibrium, we have the following lemma:

Lemma 1 *Under behavior-based pricing, the equilibrium second-period prices are:*

$$\begin{aligned} p_{j2o} &= \frac{(4N-n-3)(2v(N-n)+(n-1)t) - 2t\theta_2(N-n)(n-1) - 2t\theta_1(n-1)^2}{16N(N-n-1)+(3n+1)(n+3)}, \\ p_{j2n} &= \frac{(4N-n-3)(2v(N-n)+(n-1)t) - 4t\theta_1(n-1)(2N-n-1) - 4t\theta_2\left(2N^2-3Nn-N+n^2+n\right)}{16N(N-n-1)+(3n+1)(n+3)}, \end{aligned} \quad \textit{for} \quad v \in \left(\underline{v_l}, \overline{v_l}\right);$$

$$\begin{aligned} p_{j2o} &= \frac{t(4N-n-3-2\theta_1(n-1))}{3(n-1)}, \\ p_{j2n} &= \frac{t(2N+n-3) - 4t\theta_1(n-1)}{3(n-1)}. \end{aligned} \quad \textit{for} \quad v \in \left(\underline{v_h}, \overline{v_h}\right); \tag{8}$$

where $p_{j2o} > p_{j2n}$ in the low- and high-valuation regions.

In simple terms, when consumer valuation is low ($\underline{v_l} < v < \overline{v_l}$), it is not profitable for a consumer to travel all the way from one end of the spoke to the other end to buy a product, implying $\frac{1}{2} < \frac{v-p_j}{t} < 1$. On the other hand, when consumer valuation is high ($\underline{v_h} < v < \overline{v_h}$), it is profitable for a consumer to travel all the way from one end of the spoke to the other end to buy a product, suggesting $\frac{v-p_j}{t} \geq 1$. The valuation bounds are defined in Section B1 of Appendix B. Lemma 1 shows that the second-period price for new consumers is lower than that for old consumers.[2] Specifically, we have:

$$p_{j2o} - p_{j2n} = \begin{cases} \frac{2t((n-1)\theta_1+(N-n)\theta_2)}{4N-n-3} > 0, & \text{for} \quad v \in \left(\underline{v_l}, \overline{v_l}\right) \\ \frac{2t(N-n+(n-1)\theta_1)}{3(n-1)} > 0, & \text{for} \quad v \in \left(\underline{v_h}, \overline{v_h}\right). \end{cases} \tag{9}$$

Consistent with prior literature, we find that firm j offers a lower price to attract rivals' consumers, implying that the firm ends up milking its own consumers though rewarding competitors' consumers. When consumer valuation is low, the difference in the price paid by old and new consumers is smaller. This reduction in the price difference is due to an additional force at play when consumer valuation is smaller. Note that if the firm offers a lower second-period price for new consumers, it can generate new demand from consumers in Segment 3 (consumers who only have their second-preferred product available). However, the firm's ability to milk the old consumers in Segment 3 is limited when consumer valuation is low. This is because if the firm raises its second-period price for old consumers, some of the old consumers can no longer repeat buy the product at the high price.

Period 1. In period 1, firm j chooses the first-period price to maximize its profits. While choosing p_{j1}, firm j fully anticipates the likely impact of its first-period demand on second-period profits. Consumers are also forward looking and rationally expect that their choice in the first period will influence the price they are likely to face in the second period. Furthermore, consumers maximize their two-period utility. The first-period demand for product j comes from three segments of consumers.

Segment 1: The first-preferred and second-preferred products of consumers in this segment are available. Focusing on the marginal consumer in this competitive segment, we see two scenarios. In the first scenario, the marginal consumer purchases product j in the first period at p_{j1} and buys product k in the second period at p_{k2n}, and the resulting two-period utility derived by the consumer is:

$$U_{s1} = v - tx - p_{j1} + \delta\left(v - t\left(1 - x\right) - p_{k2n}\right), \tag{10}$$

[2] If we set $N = n = 2$, we can recover the results from the standard Hotelling model.

where $\delta \in (0,1)$ is the discount factor. In the second scenario, the marginal consumer purchases product k in the first period at p_{k1} and buys product j in the second period at p_{j2n}, and the resulting utility is:

$$U_{s2} = v - t(1-x) - p_{k1} + \delta(v - tx - p_{j2n}). \tag{11}$$

In equilibrium, the marginal consumer in the competitive segment must be indifferent between these two scenarios, implying $U_{s1} = U_{s2}$. Hence, the location of the marginal consumer is given by:

$$\theta_1 = \frac{1}{2} + \frac{p_{k1} - p_{j1} + \delta(p_{j2n} - p_{k2n})}{2t(1-\delta)}. \tag{12}$$

Given the location of the marginal consumer (see the above equation), the demand from this segment for product j is as follows:

$$\frac{2}{N}\frac{1}{N-1}\sum_{k\neq j, k\in\{1,\ldots,n\}} \max\{\min\{\theta_1, 1\}, 0\}. \tag{13}$$

Segment 2: Only the first-preferred product of the consumers in this segment is available. Recall that $\theta_2 \equiv \frac{v-p_{j1}}{t}$. Hence the first-period demand for product j from this segment is:

$$\frac{2}{N}\frac{N-n}{N-1}\min\left\{\max\{0,\theta_2\}, \frac{1}{2}\right\}. \tag{14}$$

Segment 3: Only the second-preferred product is available for consumers in this segment, and the first-period demand for product j is:

$$\frac{2}{N}\frac{N-n}{N-1}\min\left\{\max\left\{0, \theta_2 - \frac{1}{2}\right\}, \frac{1}{2}\right\}. \tag{15}$$

Taken together, the first-period demand for product j is as follows:

$$q_j = \begin{cases} \frac{2}{N}\frac{n-1}{N-1}\max\{\min\{\theta_1,1\},0\} + \frac{1}{N}\frac{N-n}{N-1} \\ \quad + \frac{2}{N}\frac{N-n}{N-1}\left(\theta_2 - \frac{1}{2}\right), & \text{for } \frac{1}{2} < \frac{v-p_j}{t} < 1 \\ \frac{2}{N}\frac{n-1}{N-1}\max\{\min\{\theta_1,1\},0\} + \frac{2}{N}\frac{N-n}{N-1}, & \text{for } \frac{v-p_j}{t} \geq 1. \end{cases} \tag{16}$$

We relegate the detailed derivation of the equilibrium price in the first period to Appendix B. Next we examine how equilibrium outcome is tempered by consumer valuation.

Effect of consumer valuation. A central finding in the behavior-based pricing literature is that price discrimination based on consumers' purchase history hurts firms' profits. We observe this because in the presence of purchase history, each firm finds it profitable to charge a higher price for old consumers and a lower price for new consumers with the goal of poaching some of the competitor's consumers. But when all firms adopt behavior-based pricing, it hurts the profits of all firms. Interestingly, in the absence of purchase history, competing firms can earn more profits (Fudenberg and Villas-Boas, 2006). The question is whether this result is sensitive to consumer valuation. On exploring this issue, we have the following proposition:

Proposition 1 *When consumer valuation is high, competing firms strictly earn lower two-period profits with BBP than without it for* $\delta \in \left(\frac{\sqrt{65}-5}{8}, 1\right)$. *However, if consumer valuation is low, competing firms can earn higher two-period profits with BBP than without it.*

The first part of the proposition shows that the spokes framework can yield the traditional result: BBP hurts the profits of competing firms if consumer valuation is high. However, the second part of the proposition shows that the result can be reversed if consumer valuation is low. Thus Proposition 1 brings to the fore that the profitability of BBP is moderated by consumer valuation.

To understand why firms can earn more profits by adopting BBP when consumer valuation is low, recall that the demand for a firm's product comes from three segments of consumers: a competitive segment where both the products in consumers' consideration are available (Segment 1), a monopoly segment where only the first-preferred product is available (Segment 2), and another monopoly segment where only the second-preferred product is available (Segment 3). When consumer valuation is low, some of the consumers in Segment 3 are not served in the first period. However, if firms leverage the purchase history and offer a lower price for new consumers in the second period, some of these otherwise neglected consumers could be served. Thus, when consumer valuation is low, behavior-based pricing helps firms to better cover the market. The resulting improvement in profits can outweigh the (negative) competitive effects of behavior-based pricing. Next we examine how diversity in consumers' tastes may affect the strategic behavior of firms.

Effect of diversity in consumers' tastes. Prior literature shows in a static setting that the prices of competing firms in an oligopoly increase with diversity in consumers' tastes if consumers valuation is high, but decrease with diversity in consumers' tastes if consumer valuation is low (e.g., Amaldoss and He, 2010). It is natural to ask whether this finding will extend to a dynamic model where firms charge targeted prices in the second period. On examining the prices set by competing firms in the first and second periods, we have the following result:

Proposition 2 *i) Under behavior-based pricing, when consumer valuation is high, the equilibrium prices in both periods strictly increase with diversity in consumers' tastes (N); if consumer valuation is low, both the first-period price and the second-period prices can increase with N. ii) When consumer valuation is high, the difference in the price charged to old and new consumers, $p_{j2o} - p_{j2n}$, strictly increases with diversity in consumers' tastes (N); whereas when consumer valuation is low, $p_{j2o} - p_{j2n}$ can decrease with diversity in consumers' tastes.*

The first part of the proposition shows that the finding observed in a one-period model extends to a two-period model of BBP when consumer valuation is high but not when consumer valuation is low. To follow the intuition, note that as consumers' tastes become more diverse, more consumers will not have the first-preferred or second-preferred product in their consideration set available, implying the monopoly segments grow in size while the competitive segment shrinks. We know that consumers in the two monopoly segments will purchase a firm's product as long as it yields a nonnegative surplus. Recognizing this, when setting its price, each competing firm carefully balances the gains from the monopoly segments against those from the competitive markets. In this context, when consumer valuation is high, the location of the marginal consumer in a competitive segment does not move or moves less due to the competitive reaction of other firms. So the firm is less motivated to cut price in order to increase its sales to the competitive segment. Furthermore, if consumer valuation is high, all consumers could gain some surplus by buying any product in their consideration set, making the consumers in the monopoly segments completely price inelastic. Consequently, the firms' prices increase with N when consumer valuation is high. This intuition applies to both periods when consumer valuation is high. Next turning attention to the case when consumer valuation is low, note that if we hold n constant and increase N, the relative size of the monopoly segments grows, and the overall demand becomes more elastic to price, provided $p < v - t$. This negative direct (demand-side) effect on price is the driving force in a one-period model. But there is a positive indirect (strategic) effect on price in a two-period model of BBP. Because forward-looking consumers anticipate firms adopting BBP to price discriminate in the second period, they are less price elastic in the first period. As this strategic effect dominates the demand effect, the equilibrium first-period price increases with N. In the second period, when N is sufficiently larger than n, the monopoly segments become so significant that the firms find it profitable to earn a higher margin from these consumers rather than cut prices. Therefore, as diversity increases in a market with relatively few alternatives, both the first-period price and the second-period prices can increase when consumer valuation is low.

To follow the intuition for the second part of the proposition, note that when consumer valuation is low, firms gain some new demand because of the lower price for new consumers, but lose some demand from old consumers because of the higher price for old consumers. The resulting price differential is moderated by the size of Segment 3, the monopoly segment where only the second-preferred product of consumers is available. Some of the consumers in this segment could potentially take advantage of the lower price for new consumers and buy the product in the second period. Holding the number of available products (n) constant, as consumers' tastes become more diverse, the size of Segment 3 increases when consumer valuation is low. In this context, the difference in the price charged to old and new consumers, $p_{j2o} - p_{j2n}$, has a non-monotone relationship with N. In particular, when consumer valuation is near the lower bound, the price differential between the old and new consumers decreases with the size of Segment 3. This occurs because under such circumstances, firms do not find it lucrative to attract new consumers, and moreover, their pricing power over the old consumers is limited. It is useful to note that the price differential can increase when consumer valuation is near the upper bound of the low-valuation region. Likewise, when consumer valuation is in the high-valuation region, the difference in second-period prices increases with diversity in taste.

A related issue is how diversity in taste affects the profits of the competing firms. We have the following result.

Proposition 3 *i) Under behavior-based pricing, when consumer valuation is high, the equilibrium two-period profits (π_j) strictly increase with diversity in consumers' tastes (N); but if consumer valuation is low, π_j can decrease with N.*

Intuitively, the equilibrium profits are functions of the equilibrium prices and demand. In the high valuation region, all consumers can purchase and gain nonnegative surplus. Therefore, the comparative statics of equilibrium profits with respect to N follows the same pattern as that of equilibrium prices when consumer valuation is high. However, if consumer valuation is low, recall that the prices can increase with diversity. The higher price helps a firm earn more profits from Segment 2 where its product is the first-preferred product, but lose sales in Segment 3 where its product is the second-preferred product. In this context, as diversity increases the loss in profits from Segment 3 comes to dominate the gain in profits from Segment 2, and the overall profits of a firm decline.

Next, the basic premise of behavior-based pricing is that firms base their prices on consumers' purchase history. It is natural to ask, therefore, what will happen if consumers also make their purchase decision based on their own purchase history? For example, when comparing products, consumers could use the previously purchased product as the benchmark or reference product. We consider this possibility in the next section.

3. REFERENCE DEPENDENCE AND BBP

Reference dependence influences the utility consumers derive from a nonreference product in two ways. When a consumer finds that a nonreference product's price is higher than the reference product's price, she experiences a psychological disutility, which increases with the size of the price difference. The consumer also suffers a psychological disutility if the match utility of a nonreference product is lower than the match utility of the reference product. Now let product j be the reference product of a category, and product k be one of the nonreference products. If the consumer located at (l_j, x) buys the reference product at price p_j, she will derive the following (indirect) utility:

$$U(l_j, x, p_z) = v - tx - p_j. \tag{17}$$

However, if the consumer purchases the nonreference product k at price p_k, the (indirect) utility derived from the product is:

$$v - p_k - t\,(1-x) - \lambda \max\{0, p_k - p_j\} - \mu t \max\{0, 1-2x\}, \tag{18}$$

where $\lambda > 0$ is a measure of the consumer's sensitivity to a price difference with the reference product, and $\mu > 0$ is a measure of the consumer's sensitivity to a match utility difference with the reference product. That is, λ and μ are the loss aversion parameters pertaining to price and match quality, respectively. In the above expression, $v - p_j - t\,(1-x)$ is the intrinsic surplus the consumer enjoys on buying the nonreference product instead of the reference product. If the nonreference product is higher priced, the consumer incurs a disutility, which is given by $\lambda \max\{0, p_k - p_j\}$. If the nonreference product offers a lower match utility, the consumer suffers a disutility given by $\mu t \max\{0, 1-2x\}$. In this formulation, reference dependence does not add to the utility of the reference product, but reduces the utility of the nonreference product when it compares unfavorably with the reference product on price or match utility.

We assume that when making their purchase decision in the second period, consumers treat the product they purchased in the first period as the reference product. In particular, they compare the second-period price and match quality of the reference product against the second-period price and match quality of the other product in their consideration set. Henceforth, we refer to this type of reference dependence as cross-sectional reference dependence.

Recall that both the products in the consideration set of the consumers in the competitive segment (Segment 1) are available. Depending on the relative prices, these consumers decide on whether to buy the reference product or the nonreference product. Note that for consumers who purchased product j in the first period, it is the reference product. Given this reference product, the location of the marginal consumer who is indifferent between products j and k is given by:

$$\widehat{x} = \begin{cases} \min\left\{1, \frac{1}{2} + \frac{1+\lambda}{2t}\left(p_{k2n} - p_{j2o}\right)\right\}, & \text{for} \quad p_{j2o} \leq p_{k2n} \\ \max\left\{0, \frac{1}{2} + \frac{1}{2t(1+\mu)}\left(p_{k2n} - p_{j2o}\right)\right\}, & \text{for} \quad p_{j2o} > p_{k2n}. \end{cases} \tag{19}$$

Likewise, product k serves as the reference product for consumers who purchased it in the first period. Given this reference product, the location of the marginal consumer who is indifferent between the two products is given by:

$$\widetilde{x} = \begin{cases} \min\left\{1, \frac{1}{2} - \frac{1+\lambda}{2t}\left(p_{j2n} - p_{k2o}\right)\right\}, & \text{for} \quad p_{k2o} \leq p_{j2n} \\ \max\left\{0, \frac{1}{2} - \frac{1}{2t(1+\mu)}\left(p_{j2n} - p_{k2o}\right)\right\}, & \text{for} \quad p_{k2o} > p_{j2n}. \end{cases} \tag{20}$$

Next, we discuss the second-period demand and prices.

Period 2. As in Section 2, we can derive the second-period demand for product j from the old consumers who had purchased the product in period 1. We have:

$$q_j = \begin{cases} \frac{2}{N}\frac{n-1}{N-1}\max\left\{\min\left\{\widehat{x}, \theta_1\right\}, 0\right\} + \frac{1}{N}\frac{N-n}{N-1} \\ \qquad + \frac{2}{N}\frac{N-n}{N-1}\left(\frac{v-p_{j2o}}{t} - \frac{1}{2}\right), & \text{for} \quad \frac{1}{2} < \frac{v-p_j}{t} < 1 \\ \frac{2}{N}\frac{n-1}{N-1}\max\left\{\min\left\{\widehat{x}, \theta_1\right\}, 0\right\} + \frac{2}{N}\frac{N-n}{N-1}, & \text{for} \quad \frac{v-p_j}{t} \geq 1. \end{cases} \tag{21}$$

Similarly, the demand for product j from new consumers who purchased product k in period 1 is as follows:

$$\widehat{q}_j = \begin{cases} \frac{2}{N}\frac{n-1}{N-1}\min\left\{\max\left\{\widetilde{x} - \theta_1, 0\right\}, \theta_1\right\} + \frac{2}{N}\frac{N-n}{N-1}\max\left\{\frac{v-p_{j2n}}{t} - \theta_2, 0\right\}, & \text{for} \quad \frac{1}{2} < \frac{v-p_j}{t} < 1 \\ \frac{2}{N}\frac{n-1}{N-1}\min\left\{\max\left\{\widetilde{x} - \theta_1, 0\right\}, \theta_1\right\}, & \text{for} \quad \frac{v-p_j}{t} \geq 1. \end{cases} \tag{22}$$

In period 2, firm j which supplies product j maximizes its profits by choosing the optimal prices for old and new consumers: p_{j2o} and p_{j2n}. Upon studying the symmetric pure strategy equilibrium, we have the following lemma.

Lemma 2 *If consumers evince cross-sectional reference dependence, then under a behavior-*

based pricing strategy the equilibrium second-period prices are:

$$\begin{array}{ll} p_{j2o} = \dfrac{(\mu+1)\begin{pmatrix} (2Nv-2nv+nt-t)(4N+4N\mu-n-4n\mu-3) \\ +2t(n-1)(\theta_1-N\theta_2-n\theta_1+n\theta_2) \end{pmatrix}}{16N(\mu+1)(N+N\mu-1)+16n\mu(n+n\mu+1)-16Nn(2\mu^2+3\mu+1)+3n^2+10n+3}, & \\ p_{j2n} = \dfrac{(\mu+1)\begin{pmatrix} (2Nv-2nv+nt-t)(4N+4N\mu-n-4n\mu-3) \\ -4t(N\theta_2-n\theta_2+n\theta_1-\theta_1)(2N+2N\mu-n-2n\mu-1) \end{pmatrix}}{16N(\mu+1)(N+N\mu-1)+16n\mu(n+n\mu+1)-16Nn(2\mu^2+3\mu+1)+3n^2+10n+3}, & \text{for } \quad v \in \left(\underline{v_l}, \overline{v_l}\right) \\ p_{j2o} = \frac{t(\mu+1)(4N-n-3-2\theta_1(n-1))}{3(n-1)}, & \\ p_{j2n} = \frac{t(\mu+1)(2N+n-3-4\theta_1(n-1))}{3(n-1)}, & \text{for } \quad v \in \left(\underline{v_h}, \overline{v_h}\right). \end{array} \tag{23}$$

where $p_{j2o} > p_{j2n}$ in both high- and low-valuation regions.

Similar to Lemma 1, Lemma 2 shows that the second-period price for new consumers is strictly lower than the price for old consumers, implying $p_{j2n} < p_{j2o}$. In particular, we have:

$$p_{j2o} - p_{j2n} = \begin{cases} 2t(\mu+1)\frac{(N-n)\theta_2+\theta_1(n-1)}{4N+4N\mu-n-4n\mu-3} > 0, & \text{for} \quad v \in \left(\underline{v_l}, \overline{v_l}\right) \\ \frac{2t(\mu+1)(N-n+(n-1)\theta_1)}{3(n-1)} > 0, & \text{for} \quad v \in \left(\underline{v_h}, \overline{v_h}\right). \end{cases} \tag{24}$$

This finding clarifies that reference dependence does not change the rank order of the second-period price for new and old consumers even though reference dependence raises both these prices.

<u>Period 1.</u> In period 1, firm j maximizes its profit by choosing the optimal p_{j1}, recognizing that the resulting demand will impact its prices in the second period. Consumers are forward looking and rationally expect that their first-period purchase will influence the price they pay in the second period. Consumers also anticipate that in the second period they are susceptible to reference dependence. Furthermore, consumers maximize their two-period utility. As in the previous section, when we focus on the marginal consumer we see two scenarios. In the first scenario, the marginal consumer purchases product j in the first period at p_{j1} and purchases product k in the second period at p_{k2n}, with the resulting utility being:

$$U_{s1} = v - tx - p_{j1} + \delta\left(v - t(1-x) - p_{k2n} - \mu t \max\{0, 1-2x\}\right). \tag{25}$$

In the second scenario, the marginal consumer purchases product k in the first period at p_{k1}

and buys product j in the second period at p_{j2n}, and she derives a total utility of:

$$U_{s2} = v - t(1-x) - p_{k1} + \delta\left(v - tx - p_{j2n} - \mu t \max\{0, 1-2x\}\right). \tag{26}$$

In equilibrium, the marginal consumer is indifferent between the two scenarios, implying $U_{s1} = U_{s2}$. It follows that the location of the marginal consumer is given by:

$$\theta_1 = \frac{1}{2} + \frac{p_{k1} - p_{j1} + \delta\left(p_{j2n} - p_{k2n}\right)}{2t(1-\delta)}. \tag{27}$$

The rest of the analysis pertaining to period 1 is similar to that discussed in Section 2. We relegate the detailed derivation to Appendix B. As in the case of behavior-based pricing without reference dependence, competing firms could adopt a penetration pricing strategy or a skimming pricing strategy depending on consumers' discount factor (δ) and consumers' sensitivity to match utility (μ). Focusing on the high-valuation region, we find that:

$$\begin{aligned} p_{j2o} - p_{j1} &= \frac{(2N-n-1)\left(6\mu + \delta + 8\delta^2 - 8\mu\delta + 8\mu\delta^2 - 3\right)}{9(n-1)} \\ &> 0 \text{ if } \mu > \frac{3 - \delta - 8\delta^2}{6 + 8\delta^2 - 8\delta}, \end{aligned} \tag{28}$$

$$\begin{aligned} p_{j2n} - p_{j1} &= \frac{t(2N-n-1)\left(3\mu + \delta + 8\delta^2 - 8\mu\delta + 8\mu\delta^2 - 6\right)}{9(n-1)} \\ &> 0 \text{ if } \mu > \frac{6 - \delta - 8\delta^2}{3 - 8\delta + 8\delta^2}. \end{aligned} \tag{29}$$

Next we proceed to examine how cross-sectional reference dependence influences equilibrium profits.

Effect of cross-sectional reference dependence on profits. According to Proposition 1, if consumer valuation is high, competing firms earn lower profits with BBP than without it. We obtain the following result if consumers are susceptible to reference dependence.

Proposition 4 *i) In the presence of loss-aversion on price, competing firms earn lower profits with BBP than without it when consumer valuation is high. ii) However, if consumers'* *loss aversion on match quality is sufficiently high, competing firms earn higher profits with BBP than without it when consumer valuation is high.*

To follow the intuition for the first part of Proposition 4, note that in equilibrium the price for new consumers is lower than that for old consumers (see equation 23). Thus in the second period when the marginal consumer switches to her second-preferred product which is a new product, she pays the lower price offered for new consumers. Consequently, the marginal consumer does not experience any loss on price and loss aversion does not affect her choice. This explains why, in keeping with Proposition 1, we find that firms earn lower profits with BBP than without it.

The second part of Proposition 4 shows that when consumers exhibit sufficient loss aversion on match quality, behavior-based pricing can turn into a blessing. Given that the price for new consumers is lower than the price for old consumers, the marginal consumers chooses a product that is further away from her ideal point, and suffers a loss on the taste dimension. We know from Proposition 1 that BBP can be beneficial to firms only when consumer valuation is low. In a key departure from the extant literature, we find that behavior-based pricing can improve firms' profits even when consumer valuation is high, provided consumers are sufficiently averse to loss on match quality. For a concrete illustration, consider the following case. Let π_j be the two-period profits when firms do not adopt behavior-based pricing, and let $\overrightarrow{\pi}_j$ be the two-period profits under BBP with cross-sectional reference dependence. If $\delta = 0.8$, $t = 1$, $N = 10$, $n = 3$, and $\mu = 0.5$, we have $\overrightarrow{\pi}_j = 1.536 > \pi_j = 1.277$. As the goal of Proposition 4 is to draw a contrast with Proposition 1, we focused attention on the high-valuation region. For completeness, note that BBP remains profitable in the low-valuation region.[3] To gain insight into what is driving the profitability of BBP, we next compare the prices under different regimes: no BBP, BBP in the absence of reference dependence, and BBP in the presence of reference dependence.

Effect of cross-sectional reference dependence on prices. Let p_j be the static price of firm j when it does not engage in behavior-based pricing. We have the following

[3] To see this, consider the case where $\delta = 0.8$, $t = 1$, $N = 10$, $n = 3$, $v = 1.2$, and $\mu = 0.5$. In this case, on adopting BBP profits increase by $\Delta\pi_j = 0.0100$. The equilibrium prices are $p_{j1} = 0.6066$, $p_{j2o} = 0.6263$, and $p_{j2n} = 0.3041$, implying that all the boundary conditions for the low-valuation region are satisfied: $\frac{v-p_{j1}}{t} = 0.5934$, $\frac{v-p_{j2o}}{t} = 0.5737$, and $\frac{v-p_{j2n}}{t} = 0.8959$.

proposition on the relative prices:

Proposition 5 *i) When consumers are not susceptible to reference dependence, firms adopting behavior-based pricing charge lower prices in the second period:* $p_j > \{p_{j2o}, p_{j2n}\}$ *for both low and high consumer valuation. ii) However, when consumers evince sufficient loss aversion on match quality, firms adopting BBP charge a higher price in the second period for new as well as old consumers. Specifically, in the high valuation region,* $p_j - p_{j2o} < 0$ *for* $\mu > \frac{1}{2}$*, and* $p_j - p_{j2n} < 0$ *for* $\mu > 2$*.*

As discussed in Section 2, firms are worse off adopting behavior-based pricing. This is because of the intense competition in the second period for new consumers. The situation is very different if consumers are susceptible to loss-aversion on match quality. When consumers use the product purchased in the first period as the reference product and compare the second-period price and match quality of the reference product against those of the new product, firms raise their prices. This rise in price changes the prior findings on BBP in two significant ways. First, prior literature finds that prices decline over time, whereas we find that prices increase with time if consumers are sufficiently loss averse to match quality (see equations 28 and 29). Second, though much of prior literature shows that BBP hurts firms' profitability, we find that in the presence of loss aversion on match quality BBP can be profitable.

4. SWITCHING COST AND BBP

Sometimes consumers incur costs when they switch from one firm's product to another firm's product (e.g., Schmalensee, 1982; Klemperer, 1987a,b). The switching costs could be a consequence of a variety of factors, such as the need to buy adapters, need to learn about a new operating system, partial compatibility of apps, and even emotional attachment to a product. At a broad level, like reference dependence, switching costs make consumers view the old product favorably. This may lead us to conjecture that switching costs may improve the profitability of behavior-based pricing in the same way that reference dependence does. We explore this issue in this section.

Suppose that consumers incur a switching cost $s > 0$ when they switch from one firm's product to another firm's product. The model formulation is similar to that described in Section 2, except that now consumers incur a switching cost. Below we first outline the second-period demand and then discuss the first-period demand.

Period 2. The switching cost does not affect the demand from the old consumers but plays a crucial role in the demand from new consumers.

Old Consumers. As discussed in Section 2, the demand from product j comes from three segments, and the aggregate demand is given by:

$$q_j = \begin{cases} \frac{2}{N}\frac{1}{N-1}\sum_{k\neq j,k\in\{1,\dots,n\}} \min\left\{\max\left\{\frac{1}{2}+\frac{p_{k2n}-p_{j2o}}{2t},0\right\},\theta_1\right\} & \text{for } \frac{1}{2}<\frac{v-p_j}{t}<1 \\ +\frac{1}{N}\frac{N-n}{N-1}+\frac{2}{N}\frac{N-n}{N-1}\left(\frac{v-p_{j2o}}{t}-\frac{1}{2}\right), & \\ \frac{2}{N}\frac{1}{N-1}\sum_{k\neq j,k\in\{1,\dots,n\}} \min\left\{\max\left\{\frac{1}{2}+\frac{p_{k2n}-p_{j2o}}{2t},0\right\},\theta_1\right\} & \text{for } \frac{v-p_j}{t}\geq 1. \\ +\frac{2}{N}\frac{N-n}{N-1}, & \end{cases} \tag{30}$$

This above demand is identical to Equation (4).

New Consumers. The switching cost affects the demand from new consumers. Below we discuss the new demand for product j from each of the three segments.

Segment 1. When consumers, who purchased product k in the first period, switch to buying product j in the second period, they incur the switching cost s. Recall that the marginal consumer who is indifferent between buying product j and product k is denoted by θ_1. Now the marginal consumer who is indifferent between buying product k again and switching to product j (instead of buying product k again) is given by:

$$\frac{2}{N}\frac{1}{N-1}\sum_{k\neq j,k\in\{1,\dots,n\}} \min\left\{\max\left\{\frac{1}{2}+\frac{p_{k2o}-p_{j2n}}{2t}-\frac{s}{2t}-\theta_1,0\right\},\theta_2\right\}. \tag{31}$$

Segment 2. Product j is the first-preferred product of consumers in this segment, and their second-preferred product is not available. We do not get any new demand from this segment.

Segment 3. For consumers in this segment, product j is the second-preferred product and their first-preferred product is not available. Now if consumer valuation is low and the second-period price for new consumers is lower, then some of the consumers in this segment who could not buy product j in the first period may be able to buy it in the second period. Recall that θ_2 gives the location of the marginal consumer who purchased product j in the first period in this monopoly. Hence, the segment of new consumers who can buy product j in the second period is given by $\frac{v-p_{j2n}}{t}-\theta_2$.

Upon aggregating the demand from the three segments, the new demand for product j in the second period is given by:

$$\widehat{q}_j = \begin{cases} \frac{2}{N}\frac{1}{N-1}\sum\limits_{k\neq j,k\in\{1,\ldots,n\}} \min\left\{\max\left\{\frac{1}{2}+\frac{p_{k2o}-p_{j2n}}{2t}-\frac{s}{2t}-\theta_1,0\right\},\theta_1\right\} & \text{for } \frac{1}{2}<\frac{v-p_j}{t}<1 \\ +\frac{2}{N}\frac{N-n}{N-1}\max\left\{\frac{v-p_{j2n}}{t}-\theta_2,0\right\}, & \\ \frac{2}{N}\frac{1}{N-1}\sum\limits_{k\neq j,k\in\{1,\ldots,n\}} \min\left\{\max\left\{\frac{1}{2}+\frac{p_{k2o}-p_{j2n}}{2t}-\frac{s}{2t}-\theta_1,0\right\},\theta_1\right\}, & \text{for } \frac{v-p_j}{t}\geq 1. \end{cases} \quad (32)$$

Based on the second-period demand, each firm sets the second-period prices for old and new consumers to maximize its profits.

Period 1. In period 1, firm j maximizes its profit by choosing the optimal p_{j1} while recognizing that the resulting demand will impact its prices in the second period. Consumers are forward looking and rationally expect that their purchase decision in the first period will influence the price they will face in the second period. Furthermore, consumers maximize their two-period utility while choosing the product to purchase in the first period. The marginal consumer in the first period faces two scenarios. First, the marginal consumer can purchase product j in the first period at p_{j1} and in the second period purchase product k at the poaching price p_{k2n}, and derive the following two-period utility:

$$U_{s1} = v - tx - p_{j1} + \delta\left(v - t\left(1-x\right) - p_{k2n} - s\right). \quad (33)$$

Alternatively, the marginal consumer can purchase product k in the first period at p_{k1} and in the second period purchase product j at the price p_{j2n}, and obtain the following two-period utility:

$$U_{s2} = v - t\left(1-x\right) - p_{k1} + \delta\left(v - tx - p_{j2n} - s\right). \quad (34)$$

In equilibrium, the marginal consumer is indifferent between the two scenarios, implying $U_{s1} = U_{s2}$. The resulting location of the marginal consumer is given by $x = \frac{1}{2} + \frac{p_{k1} - p_{j1} + \delta(p_{j2n} - p_{k2n})}{2t(1-\delta)}$. The aggregate demand in the first period is the same as that in Section 2, as shown in equation (16).

Next we discuss the impact of switching cost on the profitability of BBP, relegating the details to Appendix A. One may believe that switching cost is beneficial to a firm because it gives firms an opportunity to initially charge consumers a low price and build a user base that can subsequently be exploited by charging a higher price and earning more profits. Yet we have the following result.

Proposition 6 *If the switching cost is sufficiently high, competing firms earn lower profits with BBP than without it when consumer valuation is high.*

To follow the rationale for this finding, first note that firms adopting BBP charge different prices for old and new consumers, and consumers rationally expect firms to price discriminate in the second period. The competition for new consumers in the second period reduces second-period profits and hurts the profitability of BBP. In the presence of switching cost, firms further reduce the second-period price for new consumers as they need to compensate consumers for the switching cost. Thus switching cost exacerbates the perils of BBP. It is useful to note that switching cost has a qualitatively different effect on the profitability of BBP (Proposition 6) compared to reference dependence (Proposition 4). This is because loss aversion on match quality increases consumers' sensitivity to the difference in the match qualities of products, reduces consumers' sensitivity to price, and helps firms to raise second-period prices and earn more profits. In contrast, switching cost reduces second-period prices and aggravates the peril of BBP.

5. INTRODUCTORY PRICE, REGULAR PRICE, AND BBP

Sometimes firms announces both the introductory price and regular price. For example, Comcast's Xfinity Internet service offers consumers an attractive package. With a one-year agreement, consumers can sign up for the 150 Mbps service for \$49.99 per month. After the first year, the price will go up to \$64.95 to 66.95 per month based on area. This package may make one wonder whether such a price commitment can alleviate the perils of BBP. To analyze this issue, we use the same set up as in Section 2, except that the decision sequence is different now. In the first period, now firms simultaneously choose the first-period price (p_{j1}) and the second-period price (regular price) for old consumers (p_{j2o}). In the second period, firms choose the price for the new consumers only (p_{j2n}). As discussed in Section 2, we can divide the consumers into three segments, and derive the demand from old and new consumers. On analyzing the equilibrium profits of this model, we have the following result.

Proposition 7 *Announcing the introductory price and the regular price at the same time improves the profits from BBP. Yet firms earn higher profits without BBP than with BBP.*

Proposition 7 shows though announcing an introductory price and a regular price at the outset helps firms to earn more profits, the increase in profits is not large enough to avoid the peril of BBP. To understand the rationale for this result, first note that the firm is announcing the second-period price (regular price) in the first period itself. In essence, the firm is setting the first-period price and the second-period price for the first wave of consumers at the outset. In the second period the firm is setting the price only for the new consumers who constitute the second wave of consumers. This separation in the firms' decision making eliminates the inter-temporal relationship between the first-period price and the second-period price for old consumers, helping the firm to raise the second-period price a little for old consumers and thereby improving its profits. Still, firms continue to aggressively compete for new consumers in the second period, and this exerts such a downward pressure on profits that firms are better off without BBP than with BBP.

6. MODEL EXTENSIONS

In developing our model, we made a few simplifying assumptions to facilitate exposition of the key results. For example, in our model of reference dependence, we assumed that consumers compare the second-period price and match utility of the reference product against those of the nonreference product, and examined the impact of cross-sectional reference prices on the profitability of BBP. It is plausible that consumers use the first-period price of the reference product while evaluating the purchase options in the second period. We label this type of comparison as longitudinal reference dependence. This alternative formulation may make one wonder whether the qualitative results in the previous section are robust to how consumers form the reference price. In this section, we examine the effect of longitudinal reference dependence on the profitability of BBP. Next, recall that in our original model we assumed that a consumer considers two products. In this section, we extend the model to let consumers consider multiple products.

Longitudinal Reference Dependence. In longitudinal reference dependence, consumers compare the first-period price of the product purchased in the first period against the second-period price of the option they are evaluating. To analyze longitudinal reference dependence, we need to consider several cases: 1. $p_{j1} \leq p_{j2o} \leq p_{k2n}$, 2. $p_{j2o} \leq p_{j1} \leq p_{k2n}$, 3. $p_{j2o} \leq p_{k2n} \leq p_{j1}$, 4. $p_{k2n} \leq p_{j2o} \leq p_{j1}$, 5. $p_{k2n} \leq p_{j1} \leq p_{j2o}$, and 6. $p_{j1} \leq p_{k2n} \leq p_{j2o}$. We report the location of the marginal consumer below, relegating the detailed derivation to Appendix B.

Depending on the relative prices, consumers in the competitive segment decide on whether to buy the reference product or the nonreference product in their consideration set. Product j serves as the reference product if consumers had purchased the product in the first period. Then in the second period, the marginal consumer who is indifferent between the two products in her consideration set is given by:

$$\widehat{y} = \begin{cases} \min\left\{\max\left\{0, \frac{1}{2} + \frac{1}{2t(1+\mu)}\left(p_{k2n} - p_{j2o}\right)\right\}, 1\right\}, & \text{for} \quad p_{j1} \lesseqgtr p_{j2o}, p_{k2n} \\ \min\left\{\frac{1}{2} + \frac{\lambda(p_{k2n}-p_{j1})+(p_{k2n}-p_{j2o})}{2t(1+\mu)}, 1\right\}, & \text{for} \quad p_{j2o} \leq p_{j1} \leq p_{k2n} \\ \min\left\{\max\left\{0, \frac{1}{2} + \frac{\lambda(p_{j1}-p_{j2o})+(p_{k2n}-p_{j2o})}{2t(1+\mu)}\right\}, 1\right\}, & \text{for} \quad p_{k2n} \leq p_{j1} \leq p_{j2o}. \end{cases} \tag{35}$$

Likewise, if consumers had purchased k in the first period, then it is their reference product in the second period. In this situation, as before, we have six cases to consider: 1. $p_{k1} \leq p_{j2n} \leq p_{k2o}$, 2. $p_{k2o} \leq p_{k1} \leq p_{j2n}$, 3. $p_{k2o} \leq p_{j2n} \leq p_{k1}$; 4. $p_{j2n} \leq p_{k2o} \leq p_{k1}$, 5. $p_{j2n} \leq p_{k1} \leq p_{k2o}$, and 6. $p_{k1} \leq p_{j2n} \leq p_{k2o}$. Now the location of the marginal consumer who is indifferent between the two products in her consideration set is given by:

$$\widetilde{y} = \begin{cases} \min\left\{\max\left\{0, \frac{1}{2} - \frac{1}{2t(1+\mu)}\left(p_{j2n} - p_{k2o}\right)\right\}, 1\right\}, & \text{for} \quad p_{k1} \lesseqgtr p_{k2o}, p_{j2n} \\ \min\left\{\max\left\{0, \frac{1}{2} - \frac{\lambda(p_{j2n}-p_{k1})+(p_{j2n}-p_{k2o})}{2t(1+\mu)}\right\}, 1\right\}, & \text{for} \quad p_{k2o} \leq p_{k1} \leq p_{j2n} \\ \min\left\{\max\left\{0, \frac{1}{2} - \frac{\lambda(p_{k1}-p_{k2o})+(p_{j2n}-p_{k2o})}{2t(1+\mu)}\right\}, 1\right\}, & \text{for} \quad p_{j2n} \leq p_{k1} \leq p_{k2o}. \end{cases} \tag{36}$$

Period 2. As in the previous section, we can derive the second-period demand for product j from the old consumer. We have:

$$q_j = \begin{cases} \frac{2}{N}\frac{n-1}{N-1}\widehat{y} + \frac{1}{N}\frac{N-n}{N-1} + \frac{2}{N}\frac{N-n}{N-1}\left(\frac{v-p_{j2o}}{t} - \frac{1}{2}\right), & \text{for} \quad \frac{1}{2} < \frac{v-p_j}{t} < 1 \\ \frac{2}{N}\frac{n-1}{N-1}\widehat{y} + \frac{2}{N}\frac{N-n}{N-1}, & \text{for} \quad \frac{v-p_j}{t} \geq 1. \end{cases} \tag{37}$$

Similarly, the second-period demand for product j from new consumers is given by:

$$\widehat{q}_j = \begin{cases} \frac{2}{N}\frac{n-1}{N-1}\left(\widetilde{y} - \theta_1\right) + \frac{2}{N}\frac{N-n}{N-1}\max\left\{\frac{v-p_{j2n}}{t} - \theta_2, 0\right\}, & \text{for} \quad \frac{1}{2} < \frac{v-p_j}{t} < 1 \\ \frac{2}{N}\frac{n-1}{N-1}\left(\widetilde{y} - \theta_1\right), & \text{for} \quad \frac{v-p_j}{t} \geq 1. \end{cases} \tag{38}$$

Given the multiplicity of cases, we keep the analysis tractable by focusing attention on the case where $N = n$. We solve the game backward as in the previous section and relegate the details to Appendix B. To facilitate further discussion, let π_j be the two-period profits when firms do not adopt behavior-based pricing, $\widehat{\pi}_j$ be the two-period profits when firms adopt behavior-based pricing in the absence of reference dependence, and $\overrightarrow{\pi}_j$ and $\widetilde{\pi}_j$ be the two-period profits on pursuing behavior-based pricing in the presence of cross-sectional and longitudinal reference dependence, respectively. On comparing the equilibrium profits, we find that if consumers are sufficiently loss averse to differences in match quality, then longitudinal reference dependence can help competing firms to earn more profits with BBP than without it: $\widetilde{\pi}_j = \overrightarrow{\pi}_j > \pi_j > \widehat{\pi}_j$ for $\mu > \frac{8\delta+5}{13-8\delta}$ and $\delta > \frac{\sqrt{65}-5}{8}$. This finding is directionally consistent with the result on cross-sectional reference dependence reported in Proposition 4. We obtain this result because in the presence of longitudinal reference dependence, firms adopting behavior-based pricing can charge higher prices than the prices they can charge if not pursuing behavior-based pricing.

We know from Proposition 7 that though the announcement of the introductory price and regular price improves the profitability of BBP, firms earn lower profits with BBP than without it. This finding could raise the question of whether longitudinal reference dependence can help firms earn more profits with BBP than without BBP in such a setting. The answer is yes. We observe this result because the increase in profits facilitated by longitudinal reference dependence overcomes the peril of BBP.

Larger Consideration Set. In Section 2, we let consumers' consideration set size be two so that the Hotelling model is a special case of the spokes model. Now we extend the model to let the consideration set size be $2 \leq r \leq n$. Specifically, we assume that each consumer has a first-preferred product (on her local spoke), and $r-1$ second-preferred products (on nonlocal spokes). A representative firm j derives demand from three segments of consumers, as we specify below.

Segment 1. Consumers in this segment decide on whether to buy the first-preferred product j or the second-preferred products k_{r-1} in their consideration set depending on the relative prices of the these products, where $r-1$ is an index for the second-preferred product. Notice that for any consumer located on l_j, product k_{r-1} is her second-preferred product with probability $\frac{1}{N-1}$, where $k_{r-1} \in \{1, \ldots, n\}$ and $k_{r-1} \neq j$. The density of such consumers is $\frac{2}{N}$ because consumers are evenly distributed on all spokes. Let θ_1 denote the segment size of consumers who purchased product j in the first period. We note that the segment size of consumers who repeat purchase product j in the second period cannot exceed θ_1. Hence, the demand for product j from old consumers is as follows:

$$\frac{2}{N}\frac{1}{N-1}\sum_{k_{r-1}\neq j, k_{r-1}\in\{1,\ldots,n\}} \min\left\{\max\left\{\frac{1}{2}+\frac{p_{k2n}-p_{j2o}}{2t},0\right\},\theta_1\right\}. \tag{39}$$

A consumer makes $r-1$ pairwise comparisons between her first-preferred product and second-preferred products. She makes a unit purchase that maximizes her utility. The summation in the above equation incorporates such pairwise comparisons.

Segment 2. Because the second-preferred product of consumers in this segment is not available, they need to decide whether to buy product j or nothing. For any consumer on spoke l_j, her second-preferred variety is not available with conditional probability $\frac{N-n}{N-1}$. Thus, the demand for product j from these consumers is given by:

$$\frac{2}{N}\frac{N-n}{N-1}\min\left\{\max\left\{0,\frac{v-p_{j2o}}{t}\right\},\frac{1}{2}\right\}. \tag{40}$$

Segment 3. Consumers in this segment consider product j to be their second-preferred product. We know that for a consumer on spoke l_h, $h \notin \{1, \ldots, n\}$, product j is the second-preferred product with probability $\frac{1}{N-1}$. Moreover, the density of such consumers is

$\frac{2}{N}(N-n)$ and the demand for product j from these consumers is:

$$\frac{2}{N}\frac{N-n}{N-1}\min\left\{\max\left\{0,\frac{v-p_{j2o}}{t}-\frac{1}{2}\right\},\frac{1}{2}\right\}. \tag{41}$$

Note that the demand from each segment is the same as those when the consideration set size is two (see Section 2). We observe this outcome because the firms are symmetric in our formulation, and a firm's demand is invariant to how many pairwise comparisons consumers make before making their product choice. It then follows that increasing the consideration set size does not affect the qualitative results on the profitability of BBP reported in Proposition 1.

7. CONCLUSION

Prior literature on behavior-based pricing has explored the strategic implication of firms using purchase history to price discriminate between the old and new consumers. Our analysis of BBP addresses several significant managerial questions on the practice of BBP:

- *Can behavior-based pricing be profitable if consumer valuation is low?*

  The answer is yes. Using a model of BBP grounded in the spokes framework, we show that when consumer valuation is low, a low price for new consumers in the second period can help firms acquire additional consumers who might not purchase the product otherwise. Thus, BBP can help firms to earn higher profits when consumer valuation is low and consumers' tastes are diverse. This finding may run counter to some of the prior literature that shows BBP hurts firms' profits in a variety of situations (e.g., Chen, 1997; Villas-Boas, 2004; Acquisti and Varian, 2005; Zhang, 2011). Shin and Sudhir (2010) show that when consumers' preferences (location) are stochastic across two periods and some of them purchase multiple units, BBP can enhance firms' profits. Pazgal and Soberman (2008) show that firms with asymmetric ability to add value can benefit from BBP. Our analysis goes a step further. We consider a setting where consumers' preferences are stable over time, consumers make a unit purchase in each period, firms are symmetric, and firms have no ability to offer better products for old consumers. Yet we demonstrate that firms can benefit from adopting BBP when consumer valuation is low.

- *Can behavior-based pricing be profitable when consumer valuation is high?*

  A standard assumption in horizontal differentiation models highlighting the peril of BBP is that consumer valuation is high (Fudenberg and Villas-Boas, 2006; Zhang, 2011; Shin and Sudhir, 2010). We show that when consumer utility is reference dependent, BBP can improve competing firms' profits even if consumer valuation is high. We obtain this result because loss aversion on match quality gives firms an opportunity to raise the second-period prices and soften the competition typically observed in this period. Thus, if the loss aversion on match quality is sufficiently high, reference dependence can induce a qualitative change in the profitability of BBP. We will not observe this change in result if consumers merely evince loss aversion on price. This occurs because in equilibrium consumers pay a higher price for the reference product (old product) compared to a nonreference product (new product) and thus do not experience any loss on price.

  When evaluating a product, consumers compare both the price and match quality of the product against those of the reference product. The match utility of a product is given by the distance between a consumer's ideal point and the spatial location of the product in the market. Hence, it is straightforward to compare the match utility of a product with that of the reference product. Consumers, however, can use different anchors as the reference price of a product. In particular, the reference price of a consumer can be the past price (first-period price) of the product the consumer purchased previously or the current price (second-period price) of the product. The qualitative results of our analysis are robust to both types of reference prices.

- *Is the effect of switching cost on the profitability of BBP akin to that of reference dependence?*

  The answer is no. Recall that reference-dependent utility can make it profitable for firms to pursue BBP. On the contrary, a switching cost reduces the profitability of BBP. We find that when consumers incur a switching cost, the firm needs to offer new consumers a larger price cut to motivate them to switch. Thus, a switching cost does not eliminate the peril of BBP but rather aggravates it. Reference-dependent utility, on the other hand, softens the price competition in the second period by making consumers more sensitive to the difference in the match quality of competing products, making BBP profitable.

- *Can simultaneously announcing the introductory price and the regular price eliminate the peril of BBP?*

  By announcing both the introductory price and regular price, the firm is committing to the second-period price for old consumers. Such an announcement increases the profits from BBP. Still, firms are better off not adopting BBP because the improvement is not enough to overcome the peril of BBP.

An Exploratory Survey. Our theoretical model builds on prior empirical research on reference-dependent utility in product choice (see Neumann and Bockenholt 2014 for a meta analysis). Therefore, it may be useful to seek empirical evidence of consumers' sensitivity to loss in some product categories where firms practice BBP. Toward this goal, we surveyed 135 participants on purchase behavior for cable/satellite/internet television. The profile of our sample is as follows. Comcast and AT&T are the current service providers for 24.4% and 23.7% of the participants, respectively. We also gathered information on the least-preferred service provider (among those they considered at the time of purchase). Comcast and AT&T were considered by 30.3% and 19.2% of the participants at the time of purchase but not chosen. On average, our participants pay $98.86 per month for the service.

In our survey, we first attempt to understand how consumers' evaluation of a purchase option decreases when confronted with a loss on price. To facilitate this, we asked our participants to assume that the other member of the consideration set (not their current provider) offers the same package of channels (that they are currently viewing) at the same price (that they are currently paying); then we requested that they indicate the likelihood of adopting this alternate service provider on a ten-point scale. Furthermore, we asked them to indicate the likelihood of adopting the other service provider if it were to offer the same package of channels at a price fifty percent more than what they are currently paying. On comparing these two purchase likelihoods, we find that our participants exhibit loss aversion on price. In particular, the likelihood of purchase reduces from 2.47 to 1.27 ($t = 6.26$, $p < 0.0001$). This decrease in likelihood of purchase is consistent with consumers being sensitive to loss on price.

Second, using our survey we tried to collect evidence that is indicative of loss aversion on match quality. Toward this end, we asked our participants to indicate how likely they were to buy the package from the other service provider if it were to reduce its price by fifty percent (compared to the current price, holding fixed the package of channels). Given the lower price, the likelihood of purchase increases to 5.67. Next, we asked our participants to imagine that their relative preference for the current service provider has increased by fifty percent, but the alternative service provider offers the same package of channels at a fifty percent lower price. Now we find that the likelihood of purchasing the service from the alternate provider declines to 4.94 ($t = 6.12$, $p < 0.0001$), implying consumers are sensitive to loss on match quality. Taken together, the exploratory survey suggests that participants are sensitive to loss on both price and match quality and that both affect their choices.

Directions for further research. While this exploratory analysis provides some evidence of consumers' sensitivity to loss on price and match quality in a category where BBP is practiced, there is an opportunity to experimentally evaluate the equilibrium predictions of the model in a laboratory setting (e.g., Lim and Ho, 2007; Lim and Ham, 2013; Amaldoss and He, 2013). The current theoretical analysis considers a horizontally differentiated market where all firms are symmetric. It would be interesting to explore the implications of reference-dependent utility for behavior-based pricing in a vertically differentiated market with asymmetric firms. There is an emerging literature that tackles these issues (e.g., Pazgal and Soberman, 2008; Rhee and Thomadsen, 2017; Jing, 2017). However, the situation where consumers also base their decisions on purchase history under the aforementioned context is yet to be investigated. More generally, examining the strategic implications of context-dependence preferences is a promising avenue of research (e.g., Orhun, 2009; Ho, Lim, and Cui, 2010; Jiang, Ni, and Srinivasan, 2014).

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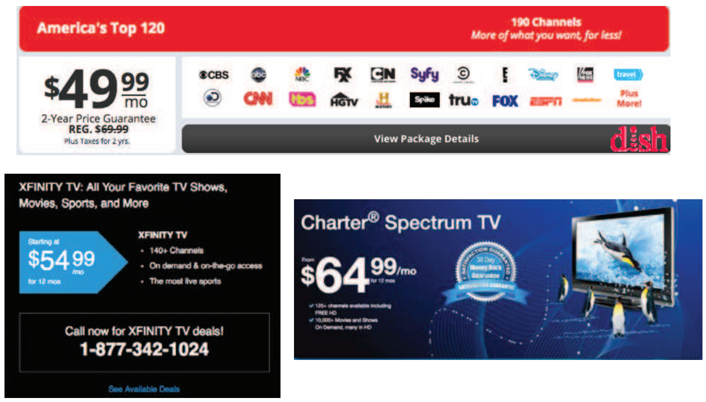
Exhibit 1

Offers from cable TV companies



Offers from credit card companies