Customer Data, Consumer Myopia and Investment in Targeting Technology*

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Abstract

We analyze investment incentives into a technology that enables firms to learn the preferences of their past customers and make targeted offers. If a firm acquires the *targeting technology*, it can practice first-degree price discrimination among consumers that bought from it in the first period. We distinguish between the cases of consumers being myopic and sophisticated. In general, it emerges as rare that firms would invest in *targeting technology*, and such investment takes place only if consumers are myopic. Our results provide insights for consumer policy that are contrary to conventional wisdom: *First*, firms are better off when consumers are sophisticated. *Second*, consumers may be better off being myopic than sophisticated. In this case requiring from firms to inform their customers about the intent to use data for future pricing is harmful for consumers.

JEL-Classification: D43; L13; L15; O30.

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1 Introduction

The rapidly improving ability of firms to collect, store and analyze customer data created large opportunities for personalized pricing and other personalized marketing activities. Customer loyalty programs provide a particularly important source of customer data for marketing purposes. Such programs are widespread in the retail and airline industries (Choi, 2013). As the CEO of Safeway Inc., the second-largest supermarket chain in the U.S. put it, "*there's going to come a point where our shelf pricing is pretty irrelevant because we can be so personalized in what we offer people*" (Ross, 2013). Airlines have also developed sophisticated techniques to utilize customer insights obtained from frequent-flyer programs (Kolah, 2013). Consumer online purchases and other types of online activities provide further important sources of customer information used in marketing.[1]

The increased use of customer data for targeted marketing activities has triggered strong reactions from consumer policy advocates. The debate has been further heated by several incidents where firms collected behavioral data and used it or sold it for marketing purposes without the awareness of consumers.[2] Consumer policy typically regards informing consumers about the consequences of their choices as highest priority and strikes down on fraudulent business practices where firms misguide consumers about these consequences. Limited consumer foresight, either a trait or a result of deliberate marketing strategy, is considered as a main source of consumer harm.[3] The argument backing this view is intuitive: If consumers are unable to or wrongly foresee the consequences of their actions, they solve the wrong optimization problem, which *per se* cannot maximize their true welfare. In this article we argue that this intuition may

[1] An anonymous computer scientist working for online retailers noted that "*...It's common for big retail web sites to direct different users to different deals, offers, or items based on their purchase histories or cookies... And companies frequently offer special deals for customers with a few items in their shopping bags-from discounts on additional items, to free shipping, to coupons for future purchases. Ingenuity, rather than price-tampering, is now the name of the game*" (Klosowski, 2013).

[2] The U.S. Federal Trade Commission recently investigated fraudulent business practices by a highly popular smartphone application developer. '*Brightest Flashlight*,' an app that allowed phones to be used as flashlight, deceived consumers about how their geolocation information would be shared with advertisers and other third parties (FTC, 2013). In a similar vein, electronics producer LG was recently accused of its smart TVs secretly recording data on consumer viewing habits that was used to display targeted advertisements, even after consumers opted out from this feature (Adams, 2013).

[3] The European Commission listed "*limited foresight and consumer myopia*" among the major channels of behavioral biases that give rise to consumer detriment. See http://ec.europa.eu/consumers/strategy/docs/study_consumer_detriment.pdf, p. 197. Retrieved on January 6, 2014. Reinforcing online privacy has been very high on the European policy agenda, see e.g., https://ec.europa.eu/digital-single-market/en/proposal-eprivacy-regulation and http://ec.europa.eu/justice/data-protection/reform/index_en.htm.

not always hold: Under very natural circumstances, when firms invest in *targeting technology* anticipating the reaction (or the absence thereof) of consumers, the latter may be better off being myopic than sophisticated.

In this article we endogenize the investment decisions of competing firms into a technology that enables them to both identify former customers and to fully recognize their brand preferences. We will call this *targeting technology*, as it allows targeting past customers with personalized prices. Endogenizing the investment step into the technology enabling price discrimination is an important distinction to existing literature, that almost without exemption takes as starting point that firms already hold data on customers and are able to use it for targeted pricing. Although in the digital age a lot of customer data arises indeed as a by-product of operations, it is not automatic that firms are able to use the gathered data to apply differentiated prices to customers. For example, launching a customer loyalty program and investing into data analytics capabilities is clearly a strategic decision, and some firms opt for it while others do not.[4] This being said, we provide an extension in which we explicitly take into account the fact that firms may produce data in their operations. In particular, while in the main analysis we assume that firms are initially unable to identify past customers, in the extension we allow firms to start out with a *tracking technology*, that enables them to recognize former customers. Our main question is, whether and when firms would take the leap to invest into a *targeting technology* that provides full information on the brand preferences of former customers and allows first-degree price discrimination among them.[5]

We consider a two-period Hotelling model. In the first period each firm decides whether to invest into *targeting technology*. In the second period firms compete and make use of the customer data they gathered in the first period for targeted pricing. When firms hold a *tracking technology* they can apply two prices, one to former customers and one to first-time buyers. With *targeting technology*, firms offer a uniform price to first-time buyers, but get the ability to first-degree price discriminate among former customers. We consider separate cases of myopic and sophisticated consumers: The former do not anticipate that customer data will be used for price discrimination and care only about current prices. In contrast, sophisticated consumers

[4] See, for example, http://www.loyalty360.org/Loyalty360/media//ResearchAndReportDocs/Bond_WP.pdf.

[5] The *tracking technology* can be thought of as a mere ability of a retailer to recognize recurring customers by their payment card details, and to apply a simple (unified) bonus at payment. The *targeting technology* corresponds well to a loyalty program where advanced data analysis is applied to purchase histories, with detailed coupons sent to former customers.

expect to get targeted offers in the second period.

A key result of our paper is that firms would rarely invest in *targeting technology* that enables them to offer individual prices to former customers. In particular, we find that in equilibrium at most one firm acquires *targeting technology*. Furthermore, this asymmetric equilibrium emerges only if consumers are myopic and firms initially do not hold the *tracking technology* and, hence, are unable to recognize the past customers. Otherwise, no firm chooses to obtain *targeting technology*. Finally, in contrast to conventional wisdom, firms always realize higher profits when consumers are sophisticated. As a result, they always have an incentive to educate consumers about the fact that their data will be used for targeted pricing. Social welfare is also higher when consumers are sophisticated. Most surprisingly, consumers can be better off when they disregard firms' ability to make use of consumer information in the second period. This is a crucial message for consumer protection policy: The fact that firms openly inform customers about their intent to use data for future pricing does not rule out harm to consumers.

The intuition for our results is as follows. Take as starting situation that firms are unable to identify former customers. If a firm invests to obtain *targeting technology*, it can offer personalized prices to former customers. With myopic consumers, the profit of the investing firm decreases in the first period, because the rival competes aggressively to prevent it from obtaining customer data through serving more consumers. However, higher second-period profits insured by the use of customer data compensate those initial losses, which renders a unilateral investment into *targeting technology* overall profitable. With sophisticated consumers, however, these investment incentives vanish. The reason is that such consumers take into account that the firm with *targeting technology* will set individual prices, which creates a sort of positive *network effect* in the first period. Each additional consumer of the firm holding *targeting technology* receives a lower individual price in the second period due to her weaker preference for the firm. This makes the firm more attractive in the first period when it already serves a lot of consumers. As a result, demand becomes *more elastic* in the first period compared to the case of myopic consumers, which leads to a more intense competition. This reduces profits and turns the investment into *targeting technology* unprofitable.

While the acquisition of *targeting technology* is individually profitable with myopic consumers, overall equilibrium industry profits are lower than when consumers are sophisticated and no investment takes place. The reason is that data on customer brand preferences intensifies competition: A firm with such data can better target the loyal consumers of the rival.[6] Firms therefore prefer consumers to be sophisticated and *educate* them. At the same time, social welfare is also lower with myopic consumers, because transport costs add up as differences in firms' ability to target customers make the distribution of consumers among them asymmetric. In contrast, consumers may gain from being myopic if lower prices offset the increased transport costs.

Finally, if initially both firms hold a *tracking technology* so that they can recognize former customers, neither of them obtains *targeting technology* even if consumers are myopic. In this case the non-investing firm competes aggressively for consumers who bought from the rival in the first period, which puts a downward pressure on the (personalized) prices of the rival holding *targeting technology*. This reduces second-period profits and results in investment being unprofitable.

The article is organized as follows. The next section discussed the relevant literature. The model is set out in Section 3. Section 4 provides the equilibrium analysis for the second period of the game. In Section 5 equilibrium incentives to acquire *targeting technology* are derived for the cases of myopic and sophisticated consumers. Section 6 provides an extension, where we allow firms to track their customers independently of their investment in targeting technology. In Section 7 we discuss the robustness of our results. Finally, the last section concludes.

2 Related Literature

Our article contributes to the literature on competitive price discrimination with demand-side asymmetries, where consumers can be classified into different groups depending on their preferences for the firms. Thisse and Vives (1988) were the first to demonstrate the famous prisoners' dilemma arising in this context, stating that each firm has a unilateral incentive to price-discriminate which eventually makes both firms worse off, because they end up offering low prices to the loyal consumers of the rival.[7] Most articles in this strand assume that customer

[6] By loyal customers of a firm we mean those that would chose a firm if prices were equal.

[7] A similar contribution is made in Shaffer and Zhang (1995) and Bester and Petrakis (1996). Other articles show that firms' ability to discriminate based on consumer brand preferences does not necessarily lead to a prisoner's dilemma. For example, in Shaffer and Zhang (2000) firms may benefit from the ability to discriminate among two consumer groups loyal to each of the firms if these groups are sufficiently heterogeneous in the strength of their loyalty. Chen et al. (2001) show that when the targeting ability of one or both firms improves (but remains imperfect), profits may increase. In Shaffer and Zhang (2002) a firm with a stronger brand loyalty may benefit from the ability to discriminate among individual consumers.

data is available exogenously. In contrast, in our main analysis a firm is able to offer individual prices to former customers only if it previously invested into *targeting technology*. We show that the prisoners' dilemma result depends crucially on the assumption whether firms are allowed to take a strategic decision (i.e., commit to) whether to obtain the technology or not. Overall, the incentives to acquire *targeting technology* turn out to be rather weak, so that in equilibrium at most one firm invests and, hence, holds some customer data. In the spirit of Thisse and Vives, joint profits over two periods are lower than compared to the no-investment case. We further qualify the prisoners' dilemma result by showing that firms avoid the reduction in profits if consumers are myopic and/or if in the no-investment case they are able to collect some customer data through simply tracking their customers.

Chen and Iyer (2002) and Liu and Serfes (2004) directly address the incentives to invest in customer data (technology). In Chen and Iyer firms can acquire a database technology allowing to approach a given share of consumers with customized prices, which is larger if a firm invests more. The authors show that full addressability never emerges in equilibrium even when the marginal cost of investment is zero, because firms try to avoid head-to-head price competition. Liu and Serfes analyze the incentives to acquire data of a given quality about consumer brand preferences, which can be used for targeted pricing. The authors show that both firms refrain from acquiring low-quality data in order to avoid the prisoners' dilemma in pricing. In these articles customer data is available exogenously. In contrast, in our analysis firms must collect data in a dynamic interaction with their customers. In such a setting we are able to analyze the role of consumer myopia for the incentives to acquire *targeting technology* and show that they are stronger when consumers are myopic.

Our article is also related to the literature on behavior-based price discrimination, where firms are able to track their first-period customers and price discriminate in the second period (see Fudenberg and Tirole, 2000, for a seminal contribution).[8] Our article differs from this literature in two ways. *First*, *targeting technology* in our analysis allows a firm not only to track its first-period customers, but also to learn their exact preferences. This difference has an impact on the elasticity of consumer demand in the first period and, hence, the intensity of price competition (provided consumers are sophisticated). In Fudenberg and Tirole first-period demand is *less* elastic compared to the case without price discrimination, such that firm realize

[8] Fudenberg and Villas-Boas (2006) as well as Esteves (2009) provide overviews of this strand of literature.

higher profits in the first period and lower profits later on.[9] This is opposite in our model, where first-period demand is *more* elastic.[10] *Second*, in an extension of our model we allow firms to start out with a *tracking technology* without investment that allows them to recognize previous buyers. We analyze their incentives to take the leap and acquire *targeting technology* in order to additionally learn the full brand preference of the customers. We show that firms choose not to invest in equilibrium to avoid the prisoners' dilemma that would result under targeted pricing with myopic and sophisticated consumers.

Finally, our article contributes to the behavioral industrial organization literature, in particular to the strand focusing on myopic consumers. Gabaix and Laibson (2006) discuss how consumer myopia can explain the existence of shrouded attributes for some consumer goods. Myopic consumers buying certain goods (e.g., printers) may not take into account the prices of complementary products (e.g., printer cartridges). Gabaix and Laibson show that in the shrouded prices equilibrium myopic consumers are worse off compared to the sophisticated ones, because they pay high prices for complementary products, while the latter benefit from the low base-good prices and substitute away from the expensive add-ons. Our results differ as we find that myopic consumers can be better off than sophisticated ones. If in the status quo without investment firms cannot track customers, with myopic consumers a firm finds it individually profitable to invest in *targeting technology*, which reduces profits and can benefit consumers. In contrast, investment incentives vanish when consumers are sophisticated.[11]

[9] Chen and Pearcy (2010) consider a modification of Fudenberg and Tirole (2000), where consumer preferences across periods are neither independent nor perfectly dependent. The authors provide an explicit solution for the case of uniformly distributed consumer preferences and also find that compared to the benchmark case without price discrimination demand in the first period is *less* elastic.

[10] In Liu and Serfes (2006) and Silbye (2010) firms compete over two periods and use customer data for targeted offers. As in our setup, these authors assume that at the end of the first period each firm collects perfect information about the own customers' brand preferences. Silbye solves the second period for an equilibrium in mixed strategies and also finds that demand in the first period is *more* elastic compared to the static case, confirming the robustness of this result. We differ from Liu and Serfes and Silbye by endogenizing firms' ability to collect customer information and also considering an asymmetric subgame where only one of the firms holds *targeting technology*.

[11] Some studies show that firms are not necessarily worse off when consumers become more sophisticated. For example, Eliaz and Spiegler (2011) introduce a model where marketing activities of the firms can influence the set of alternatives boundedly rational consumers perceive as relevant for their purchasing decisions. Profits may increase when consumers become more rational.

3 The Model

We consider a standard Hotelling model where two firms, A and B, sell two versions of the same product. Firms are located at the end points of an interval of a unit length with $x_A = 0$ and $x_B = 1$ denoting their locations. There is a mass of consumers normalized to unity. Every consumer is characterized by an address $x \in [0, 1]$ denoting her preference for the ideal product. If a consumer does not buy her ideal product, she has to incur linear transport costs proportional to the distance to the firm. The utility of a consumer with address x from buying the product of firm $i = A, B$ in period $T = 1, 2$ at the price p_i^T is

$$U_i^T(p_i^T, x) = v - t\,|x - x_i| - p_i^T,$$

where $v > 0$ is the basic utility, which is assumed to be large enough such that the market is always covered in equilibrium. Consumers buy from the firm providing higher utility.[12]

We consider a two-period game. Initially, firms hold no customer data, but can invest in obtaining a *targeting technology* that allows to learn the brand preferences of first-period customers. In the second period each firm observes the investment decision of the rival and the firm(s) with customer data can engage in first-degree price discrimination among consumers whose data it (they) gained the first period.

Period 1:

Stage 1 (Investment). Firms decide independently and simultaneously whether to invest in and obtain *targeting technology*.

Stage 2 (Competition with regular prices). First, firms publish independently and simultaneously their regular prices. Consumers observe these prices and make their purchasing decisions.

Period 2:

Stage 1 (Competition with regular prices and discounts). Firms independently and simultaneously choose their regular prices. Subsequently, the firm(s) with customer data issue(s) discounts to consumers so that blanket coupons (designed for consumer groups) are followed by targeted coupons (different for each individual consumer).

[12] We follow Liu and Serfes (2006) and use two simple tie-breaking rules. In case of a tie in utilities, the consumer chooses the closer firm if both firms have equal technologies (the consumer with $x = 1/2$ visits firm A). If technologies differ, the consumer chooses the firm with a more granular technology.

The timing of the competition stage in the second period follows Liu and Serfes (2004 and 2006) and is also consistent with a large body of literature on competitive price discrimination where firms make their targeted offers after setting regular prices (e.g., Thisse and Vives, 1988; Shaffer and Zhang, 1995, 2002; Choudhary et al., 2005). It reflects the observation that discounts issued to finer consumer groups can be changed easier than discounts (prices) targeted at broader consumer groups. Moreover, if firms decide simultaneously on regular prices and discounts (or blanket and targeted coupons), no Nash equilibrium in pure strategies may exist.[13] Depending on firms' investment choices, the timing of the competition stage in the second period is equivalent to one of the following.

First, in the subgame where both firms hold *targeting technology*, on a firm's turf the rival charges a uniform price first and the firm follows with targeted prices.[14] *Second*, in the subgame, where only one firm holds *targeting technology*, the rival chooses a uniform price to all consumers first and the firm follows with a uniform price on the rival's turf and targeted prices on the own turf. This equivalence is based on the following argument. Consider, for instance, a subgame where only one firm holds customer data. In the absence of targeting costs it will target all consumers on its turf, irrespective of the rival's regular price. Indeed, a firm with customer data can always charge a sufficiently high regular price followed by a zero blanket coupon to consumers on its turf (and a proper blanket coupon to consumers on the rival's turf) and then issue the respective targeted coupons to the latter. This makes its regular price as well as the blanket coupon to consumers on the own turf irrelevant and gives rise to sequential timing where a firm without customer data serves as a price leader.[15]

We assume that firms maximize the discounted sum of profits over two periods using a common discount factor $\delta \in (0, 1]$. We distinguish between the cases with myopic and sophisticated consumers. The former take into account only the prices in the current period when making purchasing decisions, because they do not realize that the firm(s) with *targeting technology* will use customer data collected in the first period for price discrimination in the second period. In contrast, sophisticated consumers maximize the discounted sum of utility over both periods. As is quite common in the literature, we assume that sophisticated consumers use the same

[13] In a model where firms learn the exact preferences of their first-period customers, Silbye (2010) shows that no Nash equilibrium in pure strategies exists in the second period and solves for an equilibrium in mixed strategies.

[14] Under a firm's turf we understand those consumers who bought from the firm in the first period.

[15] See Liu and Serfes (2004, p. 677) who first made a similar argument.

discount factor as the firms.[16] We also use this discount factor to compute the discounted consumer surplus over two periods when consumers are myopic. We seek for a subgame-perfect Nash equilibrium and start the analysis from the second period.[17]

4 Equilibrium Analysis of the Second Period

Depending on whether firms invest in *targeting technology* three types of subgames can emerge in the investment stage of the first period: *i)* one firm invests, *ii)* both firms invest, *iii)* no firm invests. In the latter case the game reduces to two independent static Hotelling models, where in equilibrium firms charge prices $p_A^T = p_B^T = t/2$ $(T = 1, 2)$ and each serves half of the market. To the cases *i)* and *ii)* we will refer as *asymmetric* and *symmetric* subgames and will denote them with the subscripts "As" and "S," respectively. We will assume that in the asymmetric subgame firm A is the one with *targeting technology* .

Let $\alpha^1(p_A^1, p_B^1)$ denote the market share of firm A in the first period. To simplify notation, we will sometimes refer to this share with α^1. We assume that consumers with brand preferences $x \leq \alpha^1$ $(x > \alpha^1)$ bought from firm A (B) in the first period.[18] To the former (latter) group of consumers we will refer as the *turf* of firm A (B). We denote the market share of firm A in the second period as $\alpha^2(p_A^2, p_B^2)$. Furthermore, we will call consumers with $x \leq 1/2$ $(x > 1/2)$ as the *loyal* consumers of firm A (B), because they would buy at firm A (B) in case of equal prices.

Asymmetric subgame. In the second period firm A can discriminate among consumers on its turf and has to charge a uniform price to consumers on the turf of Firm B. The latter in contrast has to offer a uniform price to all consumers. The following Lemma characterizes the equilibrium of the second period for any α^1.[19,20]

[16] The same assumption is made in Klemperer (1995), Chen (1997), Fudenberg and Tirole (2000) and Liu and Serfes (2006). In Section 7 we discuss how our results would change if consumers and firms discounted differently.

[17] Unlike Fudenberg and Tirole (2000) who have a game with incomplete information and, hence, solve for a perfect Bayesian equilibrium, our game is with complete information. In Fudenberg and Tirole (2000) a firm knows only whether a given consumer bough from it or from the rival in the first period. Hence, firms should form beliefs about the preferences of consumers in those two groups. We assume, in contrast, that *targeting technology* allows firms to observe the (exact) preferences of consumers it served in the first period. Since the market is always covered in equilibrium, all other consumers bough from the rival, such that a firm holding *targeting technology* also knows which consumers were served by the rival.

[18] We show below that this holds in any subgame, symmetric and asymmetric.

[19] In the Appendix we provide the proofs of Propositions 1-3. The proofs of all the lemmas and of Proposition 4 can be found in the Online Appendix.

[20] In Lemma 1 we state the rounded critical value of the market share of firm A in the first period: $\left(3 - \sqrt{2}\right)/2 \approx$

Lemma 1. *(Second period. Asymmetric subgame.) Assume that only firm A invested in targeting technology in the first period. The equilibrium of the second period depends on the size of firm A' s first-period market share (turf) as follows.*

i) If it is relatively small, $\alpha^1 \lessapprox 0.79$*, firm B loses consumers on its turf and serves only those with* $x > (5+2\alpha^1)/8$*. Firm B charges the price* $p_B^{2,As}(\alpha^1) = t(3-2\alpha^1)/2$*. The discriminatory price of firm A is* $p_A^{2,As}(x;\alpha^1) = t\left(3-2\alpha^1\right)/2 + t(1-2x)$*, on the turf of firm B it charges the price* $p_A^{2,As}(x;\alpha^1) = t\left(5-6\alpha^1\right)/4$*. Firms realize profits:* $\Pi_A^{2,As}(\alpha^1) = t\left[-28\left(\alpha^1\right)^2 + 20\alpha^1 + 25\right]/32$ *and* $\Pi_B^{2,As}(\alpha^1) = t(3-2\alpha^1)^2/16$*.*

ii) If it is relatively large, $\alpha^1 \gtrapprox 0.79$*, firm A loses consumers on its turf and serves only those with* $x \le 0.75$*. Firm B charges the price* $p_B^{2,As}(\alpha^1) = t/2$*. The discriminatory price of firm A to consumers with* $x \le 0.75$ *is* $p_A^{2,As}(x;\alpha^1) = t/2 + t(1-2x)$*, to all other consumers firm A charges the price* $p_A^{2,As}(x;\alpha^1) = 0$*. Firms realize profits* $\Pi_A^{2,As}(\alpha^1) = 9t/16$ *and* $\Pi_B^{2,As}(\alpha^1) = t/8$*.*

In the asymmetric subgame firm A has a competitive advantage in the second period as it holds customer data on the preferences of consumers on its turf and can also estimate the average preference on firm B's turf. Customer data allows firm A to increase its market share in the second period. However, this only happens if firm A's turf is not too large ($\alpha^1 \lessapprox 0.79$). Otherwise consumers' preferences for the rival's product are strong enough there, so that the less loyal of them switch to firm B. Similarly, the equilibrium price of firm B depends on the size of firm A's turf.[21] With its uniform price, firm B has to trade off gaining additional market shares and extracting rents from its more loyal customers. If $\alpha^1 \lessapprox 0.79$, keeping consumers on its turf is costly for firm B given the rival's better targeting ability. As a result, firm B resorts to a rent-extraction strategy by charging a relatively high price ($p_B^{2,As}(\alpha^1) = t(3-2\alpha^1)/2 \ge p_B^{2,As}(\alpha^1) = t/2$ for any α^1) and loses market shares. When α^1 increases, consumers on firm A's turf in general show a weak preference for it, so that firm B can easily compete for them. As a result, firm B switches to a market-expansion strategy by charging a relatively low price in order to gain market shares.

We now consider the equilibrium prices of firm A. Using customer data, in the second period firm A anchors its discriminatory prices to the uniform price of firm B and tries to make any consumer on its turf indifferent between the two products whenever possible with a non-

0.79.

[21] The Online Appendix provides a graphical illustration of the equilibrium prices and consumer utility in the second period of both the asymmetric and symmetric subgames.

negative price. When its first-period market share is not very large ($\alpha^1 \lessapprox 0.79$), firm A serves all consumers on its turf in the second period with a positive price. It also charges a positive uniform price to consumers on firm B's turf, which decreases in α^1 when these consumers become less loyal to firm A. As the turf of firm A becomes larger ($\alpha^1 \gtrapprox 0.79$), firm B reduces its uniform price. As a result, in the second period firm A can retain only the most loyal consumers on its turf who again pay positive prices. In contrast, the less loyal consumers on its turf switch to the rival and firm A cannot do better than offering them the price of zero.[22] Similarly, firm A's uniform price on the turf of firm B also reduces to zero. In this case firm A makes use of only a fraction of the customer data it collected in the first period. Precisely, it cannot discriminate among the least loyal consumers on its turf and has to charge them the uniform price (of zero).

We now consider how profits $\Pi_A^{2,As}(\cdot)$ and $\Pi_B^{2,As}(\cdot)$ change with α^1. On the interval $\alpha^1 \lessapprox 0.79$, where the second-period market share of firm A increases in α^1, the profit of firm A first increases and then starts to decrease. The latter happens because the uniform price of firm B, which decreases in α^1, puts a downward pressure on firm A's discriminatory prices. When firm B switches to a market-expansion strategy (at $\alpha^1 \approx 0.79$), the profit of firm A decreases abruptly and does not change with a further increase in α^1, because α^1 affects neither its prices nor its market share.[23] On the interval $\alpha^1 \lessapprox 0.79$ both the uniform price and the market share of firm B decrease in α^1, so does its profit. On the interval $\alpha^1 \gtrapprox 0.79$, where firm B adopts a market-expansion strategy both its uniform price and the market share remain constant, so that the profit of firm B does not change in α^1 either. It is straightforward that for any size of firm A's turf, its profits are higher than those of the rival.

Symmetric subgame. In the second period each firm can discriminate among consumers on its turf. The following lemma states the equilibrium of the second period depending on α^1.

Lemma 2. *(Second period. Symmetric subgame.) Assume that both firms invested in targeting technology in the first period. The equilibrium of the second period depends on the size of firm A's first-period market share (turf) as follows.*

i) If it is relatively small, $\alpha^1 \leq 0.5$, *then on the turf of firm A firms charge prices* $p_A^{2,S}\left(x;\alpha^1\right) =$

[22] To make those consumers indifferent, firm A would need to charge negative prices, which we rule out by assumption.

[23] Klemperer (1995, p. 523) identifies a similar effect in a model with switching costs, where a firm can be worse off from gaining a larger market share in the first period, because this makes the rival much more aggressive in the second period. Precisely, the latter switches discontinuously from a high-price strategy (to exploit its old consumers) to a low-price strategy (to gain new consumers).

$t\left(1-2x\right)$ and $p_B^{2,S}\left(x;\alpha^1\right)=0$, where firm A serves all consumers. On the turf of firm B prices are $p_A^{2,S}\left(x;\alpha^1\right)=t\left(1-2\alpha^1\right)/2$ and $p_B^{2,S}\left(x;\alpha^1\right)=\max\left\{t\left(1-2\alpha^1\right)/2+t\left(2x-1\right);0\right\}$, where firm A serves consumers with $x<\left(2\alpha^1+1\right)/4$. Firms realize profits $\Pi_A^{2,S}\left(\alpha^1\right)=t\left[-4\left(\alpha^1\right)^2+4\alpha^1+1\right]/8$ and $\Pi_B^{2,S}\left(\alpha^1\right)=t\left[4\left(\alpha^1\right)^2-12\alpha^1+9\right]/16$.

ii) If it is relatively large, $\alpha^1>0.5$, then on the turf of firm A firms charge prices $p_A^{2,S}\left(x;\alpha^1\right)=\max\left\{t\left(1-2x\right)+t\left(2\alpha^1-1\right)/2;0\right\}$ and $p_B^{2,S}\left(x;\alpha^1\right)=t\left(2\alpha^1-1\right)/2$, where firm A serves consumers with $x\leq\left(2\alpha^1+1\right)/4$. On the turf of firm B firms charge prices $p_A^{2,S}\left(x;\alpha^1\right)=0$ and $p_B^{2,S}\left(x;\alpha^1\right)=t\left(2x-1\right)$, where firm B serves all consumers. Firms realize profits $\Pi_A^{2,S}\left(\alpha^1\right)=t\left[4\left(\alpha^1\right)^2+4\alpha^1+1\right]/16$ and $\Pi_B^{2,S}\left(\alpha^1\right)=t\left[-4\left(\alpha^1\right)^2+4\alpha^1+1\right]/8$.

Note that in equilibrium every firm serves all the loyal consumers on its turf, because data on their preferences allows undercutting any uniform price of the rival. In contrast, a firm loses consumers on its turf if in the first period it served some of the loyal consumers of the rival.[24]

We now turn to the change in profits depending on α^1. As firms are symmetric, the explanation will focus on firm A. If $\alpha^1\leq 0.5$, firm A's profit increases in α^1 for two reasons. First, firm A is able to extract more rents on its turf, because it gains more data on its loyal consumers, and the negative competition effect is absent as firm B cannot go below the price of zero. Second, firm A increases its market shares on firm B's turf. If $\alpha^1>0.5$, the profit of firm A increases in α^1, despite the fact that it loses market shares. This is so due to the higher rents firm A realizes on its turf, because it faces a positive competition effect driven by an increase in the uniform price of firm B, which targets on firm A's turf on average more loyal consumers when α^1 gets larger. As a result, the profits of firm A increase for any α^1. Nevertheless, firm A's profits in the symmetric subgame reach the profit level in the subgame where neither firm invested in targeting technology only if it holds data on more than 90 percent of consumers in the market (precisely, if $\alpha^1>\sqrt{2}-1/2\approx 0.91$). The reason is that in the symmetric subgame each firm can distinguish between its own loyal consumers and those of the rival, and prices aggressively to the latter group. Precisely, for any $\alpha^1\leq 0.5$ firm B charges zero to firm A's loyal customers that bought from the latter in the first period. This result is similar to Thisse and Vives (1988), where competition between price- discriminating firms lowers profits.

Our results differ in two ways from Fudenberg and Tirole (2000), where in the second period

[24] Note that this is different in the asymmetric subgame, where firm B does not hold data on consumers on its turf. In that case in the second period firm A even expands its market shares among the loyal consumers of the rival (provided $\alpha^1\lessapprox 0.79$ holds).

firms can only distinguish between consumers on the two turfs. *First*, in that model a firm may lose its former loyal customers, because without the exact preference data it is restricted to charge a uniform price on its turf. Then if its turf is relatively large, a firm prefers to extract rents from its more loyal customers and allow the less loyal ones to switch to the rival. *Second*, our finding of a positive monotone relationship between the size of a firm's first period market share and its second-period profits differs from Fudenberg and Tirole, where this relationship is U-shaped (under uniform consumer distribution). In that model profits are lowest when firms' turfs are equal, in which case each firm can perfectly separate its own loyal consumers from those of the rival, and competition is most intense. Profits are highest if one of the firms served all consumers in the first period, because this outcome is least informative leading to the weakest competition. In contrast, in our model if a firm did not serve any consumers in the first period, it holds no customer data and realizes the lowest profits in the second period.

5 Equilibrium Incentives to Acquire Targeting Technology

5.1 Myopic Consumers

Myopic consumers do not foresee that the firm having invested in targeting technology will use the collected data for price discrimination in the second period. Hence, the address of the indifferent consumer in the first period, $\alpha^1(p_A^1, p_B^1)$, is given by a standard expression: $\alpha^1(p_A^1, p_B^1) = 1/2 - \left(p_A^1 - p_B^1\right)/(2t)$. The following lemma summarizes our results on the equilibrium in the asymmetric subgame with myopic consumers, where the equilibrium variables have the subscript "m."

Lemma 3. *(First period. Asymmetric subgame. Myopic consumers.) Assume that only firm A invested in targeting technology and consumers are myopic. In equilibrium in the first period firm A charges a higher price than the rival, with* $p_{A,m}^{1,As}(\delta) = t\left(24 + 5\delta - 4\delta^2\right)/(5\delta + 24)$ *and* $p_{B,m}^{1,As}(\delta) = t\left(24 - \delta - 4\delta^2\right)/(5\delta + 24)$. *At the same time, it serves less consumers than firm B, precisely, those with* $x \leq (24 - \delta)/(10\delta + 48)$. *Over two periods firm A (B) realizes higher (lower) profits compared to the subgame where neither firm acquires the technology.*

Since firms maximize the discounted sum of profits, they distort first-period prices for higher second-period profits. The profits of firm B in the second period decrease in the size of firm A's turf (provided α^1 is not very large, which is the case in equilibrium). Then in the first period firm B charges a relatively low price to prevent the rival from gaining additional customer data. In contrast, firm A charges a relatively high price in the first period, and trades off obtaining less customer data for higher second-period profits by making firm B price less aggressively then. As a result, in the first period firm A serves less consumers than the rival and gains data only on its most loyal consumers.

As firms distort their first-period prices to increase profits in the second period, each reaps lower profits in the first period than in the subgame where neither firm invests in targeting technology. However, in the second period the profits of firm A increase in the second period due to its informational advantage, and its discounted profits over two periods are higher, while the profits of firm B over two periods are lower compared to the subgame where firms do not invest. We next consider the symmetric subgame with myopic consumers. The following lemma summarizes our results.

Lemma 4. *(First period. Symmetric subgame. Myopic consumers.) Assume that both firms invested in targeting technology and consumers are myopic. Two asymmetric equilibria exist. In the first period firm i charges a higher price than the rival: $p_{i,m}^{1,S}(\delta) = t\left(12 - \delta - \delta^2\right)/(12+\delta)$ and $p_{j,m}^{1,S}(\delta) = t\left(12 - 3\delta - \delta^2\right)/(12+\delta)$, $i, j = A, B$ and $i \neq j$. At the same time, it serves less consumers than firm j, precisely, $\alpha_{i,m}^{1,S}(\delta) = (12-\delta)/[2(12+\delta)]$. Over two periods firm i realizes lower profits than its rival, while both firms are worse off compared to the subgame where none of them holds the technology.*

Interestingly, in the symmetric subgame two non-trivial asymmetric equilibria emerge in the first period, where firms charge different prices. This result is driven by the fact that the second-period profit of a firm is given by two different functions depending on whether the firm had a larger or a smaller market share in the first period (see Lemma 2). The firm with a smaller turf has a weak incentive to reduce its first-period price, because its second-period profits would increase slowly. On the other hand, a firm with a larger turf has a weak incentive to increase its first-period price, because its second-period profits would then decrease fast.

Firms are worse off in both periods compared to the subgame without targeting technology, where each firm realizes the profit of $t/2$. Second-period profits are low because of increased competition due to price discrimination. First-period profits are low, because firms compete intensively for market shares to collect more customer data. We stop for a moment to compare our results with those in a similar two-period setting with switching costs. The general result of this literature is that switching costs reduce first-period profits because firms compete aggressively for market shares, which will be valuable for them in the future (see, for instance, Klemperer, 1995 and Chen, 1997). Similarly, in our model competition is intense in the first period, because a firm with more customers will hold more data in the second period. However, different from this literature, in our model firms are not always able to compensate low first-period profits with higher subsequent profits (compare with Chen, 1997). In the next proposition we summarize the incentives to invest in targeting technology in the first period when consumers are myopic. We solve for a subgame-perfect Nash equilibrium in pure strategies.[25,26]

Proposition 1. *(Myopic consumers. Investment incentives and welfare.) If consumers are myopic, two asymmetric equilibria exist, where either one of the firms invests in targeting technology. Compared to the case where neither firm holds the technology, over two periods:*
i) total industry profits decrease,
ii) consumer surplus increases if $\delta \gtrapprox 0.9$ *and decreases otherwise and*
iii) social welfare decreases.

If the rival does not invest in targeting technology, each firm has a unilateral incentive to do that. As Lemma 3 showed, the investing firm realizes lower profits in the first period compared to the case where it does not invest, but this is compensated by higher second-period profits due to its informational advantage. However, investment incentives vanish if the rival also obtains targeting technology. This is because competition then intensifies in both periods. As a result, an asymmetric equilibrium emerges in which only one firm invests. This result is similar to Chen and Iyer (2002) where ex-ante symmetric firms make asymmetric investments into obtaining customer data to weaken competition.[27]

While over two periods the firm holding targeting technology realizes higher profits, joint profits are lower than in the case where neither firm invests. In equilibrium social welfare is also lower than without investment. This is because the asymmetric investment decisions

[25] While we only consider equilibria in pure strategies, there also exists a (symmetric) Nash equilibrium in mixed strategies, where each firm invest in targeting technology with probability $1/(1+a) \in (0,1)$, where $a := \left[\Pi_{B,m}^{1+2,As}(\delta) - \Pi_{A,m}^{1+2,S}(\delta)\right] / \left[\Pi_{A,m}^{1+2,As}(\delta) - t(1+\delta)/2\right]$.

[26] In Proposition 1 we state the rounded critical value of the discount factor: $\left(3\sqrt{69}-15\right)/11 \approx 0.9$.

[27] Our model predicts that the firm investing in targeting technology, gains market shares over time. This dynamic pattern seems to be consistent with the development of Tesco's market share in the U.K. One year after the introduction of its revolutionary Clubcard loyalty scheme in 1995, Tesco became the country's top supermarket chain (see Winterman, 2013).

result in asymmetric market shares in both periods. The consequent misallocation of consumers increases allocative inefficiency. Consumer surplus can be higher than in the case where neither firm obtains targeting technology, provided $\delta \gtrapprox 0.9$ holds. In that case consumers benefit more from lower prices than their loss due to higher transport costs.

5.2 Sophisticated Consumers

Sophisticated consumers correctly anticipate that a firm holding targeting technology will use the data collected in the first period for personalized pricing in the second period and adjust their first-period demand accordingly. As before, we consider in turn each subgame (asymmetric and symmetric) and start with the derivation of consumer demand in the first period. The subscript "s" refers to equilibrium values with sophisticated consumers.

Asymmetric subgame. The following lemma states consumer demand in the first period in the asymmetric subgame.

Lemma 5. *(First period. Asymmetric subgame. Sophisticated consumers. Demand.) Assume that only firm A invested in targeting technology and consumers are sophisticated. Then the demand of firm A in the first period is given by:*

$$\alpha_s^{1,As}(p_A^1, p_B^1) = \begin{cases} 1 & \text{if} \quad p_A^1 < p_B^1 - t \\ \frac{1}{2} + \frac{p_B^1 - p_A^1}{2t} & \text{if} \quad p_B^1 - t \leq p_A^1 < p_B^1 - t\left(2 - \sqrt{2}\right) \\ \frac{t(4-5\delta)+4\left(p_B^1 - p_A^1\right)}{2t(4-3\delta)} & \text{if} \quad p_B^1 - t\left(2-\sqrt{2}\right) - \frac{\delta t\left(3\sqrt{2}-4\right)}{4} \leq p_A^1 \leq p_B^1 + \frac{t(4-5\delta)}{4} \\ 0 & \text{if} \quad p_A^1 > p_B^1 + \frac{t(4-5\delta)}{4}. \end{cases} \tag{1}$$

If $\delta \to 0$, firm A's first-period demand (1) corresponds to a standard market-share formula: $\alpha_s^{1,As}(p_A^1, p_B^1) = 1/2 + \left(p_B^1 - p_A^1\right)/(2t)$. Otherwise, there are two differences to the latter expression. *First*, demand is discontinuous and *second,* it is given by a correspondence such that if firm A charges a moderate price, $\widetilde{p} \leq p_A^1 < \widehat{p}$ (with $\widetilde{p} := p_B^1 - t(2-\sqrt{2}) - \delta t(3\sqrt{2}-4)/4$ and $\widehat{p} := p_B^1 - t(2-\sqrt{2})$), it can attract either relatively few or many consumers. Both properties are related to the change of the equilibrium in the second period at the point $\alpha^1 \approx 0.79$ (see Lemma 1).

To understand the behavior of the demand function, consider the consumer $x = \alpha^1$, who is indifferent between the two firms in the first period. If $\alpha^1 \gtrapprox 0.79$, firm A loses market shares in the second period. Then independently which firm the indifferent consumer bought from in the first period, she will visit firm B in the second period, which charges the same price to consumers on both turfs.[28] Hence, the address of the indifferent consumer is given by a standard formula, which only balances the consumer's transport costs with the difference in prices in the first period: $\alpha_s^{1,As}(\cdot) = 1/2 + \left(p_B^1 - p_A^1\right)/(2t)$. If $\alpha^1 \lessapprox 0.79$, firm A gains market shares in the second period beyond its first-period turf. In that case, regardless which firm the indifferent consumer bought from in the first period, she will visit firm A in the second period. However, the price of the second-period purchase will be higher in case of buying at firm A, because it will learn consumer's preference. Hence, to make the consumer $x = \alpha^1$ indifferent, first-period prices should not only correspond to consumer's transport costs, on the top of that the price of firm A has to be low enough to compensate the consumer for a (discounted) higher price in the next period, which yields the demand: $\alpha_s^{1,As}(\cdot) = \left[t(4-5\delta) + 4\left(p_B^1 - p_A^1\right)\right]/\left[2t(4-3\delta)\right]$. This change in the address of the indifferent consumer is responsible for demand multiplicity around $\alpha^1 \approx 0.79$. If prices are moderate ($\widetilde{p} \leq p_A^1 < \widehat{p}$), then the market share of firm A can be both slightly smaller and larger than 0.79. Precisely, when $\alpha^1 \lessapprox 0.79$, the consumer $x = \alpha^1$ has a relatively strong preference for firm A making her indifferent between both products while taking into account the high price of firm A in the next period due to preference revealing. If $\alpha^1 \gtrapprox 0.79$, then the consumer $x = \alpha^1$ has a relatively weak preference for firm A and can only be made indifferent between both firms if revealing her preference to firm A does not create disutility in the next period.

If $\alpha^1 \lessapprox 0.79$, then in the first period firm A faces a *more* elastic demand than if $\alpha^1 \gtrapprox 0.79$. In the former case upon buying at firm A in the first period, in the second period any consumer returns to firm A at a discriminatory price. This price is lower for any additional consumer firm A gains in the first period because of her weaker preferences. This creates a sort of positive *network effects* and increases the incentives for a consumer to choose firm A when more other consumers made the same choice. As a result, for a given price reduction by firm A more consumers want to buy from it in the first period than in the case $\alpha^1 \gtrapprox 0.79$, where firm A cannot fully make use of its data in the second period such that network effects are absent

[28] Although firm A learns the preference of the indifferent consumer, it cannot make use of this data in the future. The price of the rival is so low in the second period that firm A would have to charge a negative price to keep her, which is not allowed.

then.[29] The next lemma characterizes the equilibrium in the first period.[30]

Lemma 6. *(First period. Asymmetric subgame. Sophisticated consumers.) Assume that only firm A invested in targeting technology and consumers are sophisticated. In equilibrium in the first period firm A charges a lower price and serves less consumers than the rival:*
i) If the discount factor is small, $\delta \lessapprox 0.78$*, then both firms charge positive prices, with* $p^{1,As}_{A,s}(\delta) = t(96 - 140\delta + 21\delta^2)/(96 - 52\delta)$ *and* $p^{1,As}_{B,s}(\delta) = t(96 - 132\delta + 25\delta^2)/(96 - 52\delta)$*. Firm A serves consumers with* $x \leq (24 - 23\delta)/(48 - 26\delta)$*.*
ii) If the discount factor is moderate, $0.78 \lessapprox \delta \lessapprox 0.86$*, then only firm B charges a positive price, with* $p^{1,As}_{B,s}(\delta) = t(16 - 24\delta + 7\delta^2)/(32 - 28\delta)$*. Firm A serves consumers with* $x \leq (7\delta - 6)/(7\delta - 8)$*.*
iii) If the discount factor is large, $\delta \gtrapprox 0.86$*, then only firm B charges a positive price and serves consumers, with* $p^{1,As}_{B,s}(\delta) = t(5\delta - 4)/4$*.*

Over two periods firm A realizes higher profits than the rival if $\delta \lessapprox 0.97$ *and (weakly) lower profits otherwise. Each firm realizes over two periods lower profits than in the case where neither of them obtains targeting technology.*

Firm A charges a positive price and serves some consumers in the first period only if the discount factor is sufficiently small ($\delta \lessapprox 0.78$). Under a higher discount factor ($0.78 \lessapprox \delta \lessapprox 0.86$) firm A has to reduce its first-period price to zero in order to attract some consumers. If the discount factor gets even larger ($\delta \gtrapprox 0.86$), firm A has no customers in the first period, even though it charges zero, while the rival's price is positive. Sophisticated consumers correctly anticipate that if they buy at firm A in the first period it will discriminate in the second period based on their preferences, and reduce the demand for firm A. As a result, under any discount factor over two periods firm A realizes lower profits than in the subgame where neither firm holds targeting technology. This is different in the asymmetric subgame with myopic consumers, where lower first-period profits of firm A are compensated by higher profits in the second period. Precisely, with myopic consumers first-period profits of firm A are low for two reasons. First, firm B prices aggressively to prevent firm A from gaining customer data. Second, firm A charges a relatively high price to serve less consumers in the first period to make firm B price softer in the second period. With sophisticated consumers firm A suffers additionally from a reduction

[29] As established in Lemma 1, to the less loyal consumers on its turf (including the indifferent consumer of the first period) firm A offers the uniform price of zero in the second period, because it cannot make them indifferent between the two products with any positive price.

[30] Lemma 6 uses rounded critical values of the discount factor: $\left(70 - 2\sqrt{721}\right)/21 \approx 0.78$ and $6/7 \approx 0.86$.

in the first-period demand, and these losses cannot be anymore compensated by higher profits in the second period. Interestingly, unlike with myopic consumers, the profits of firm A over two periods may be smaller than those of the rival when consumers are sophisticated (if $\delta \gtrapprox 0.97$). In that case firm B charges in the first period the highest price at which it can serve all consumers ($p_{B,s}^{1,As}(\delta) = t(5\delta - 4)/4$). When consumers discount the future only slightly, this price increase such that firm B realizes higher profits than firm A.[31]

Symmetric subgame. The following lemma describes consumer demand in the first period in the symmetric subgame.

Lemma 7. *(First period. Symmetric subgame. Sophisticated consumers. Demand.) Assume that both firms obtained targeting technology and consumers are sophisticated. Then the demand of firm A in the first period is given by:*

$$\alpha_s^{1,S}\left(p_A^1, p_B^1\right) = \begin{cases} 0 & \text{if} \quad p_A^1 - p_B^1 > \frac{t(2-\delta)}{2} \\ \frac{1}{2} - \frac{p_A^1 - p_B^1}{t(2-\delta)} & \text{if} \quad -\frac{t(2-\delta)}{2} \leq p_A^1 - p_B^1 \leq \frac{t(2-\delta)}{2} \\ 1 & \text{if} \quad p_A^1 - p_B^1 < -\frac{t(2-\delta)}{2}. \end{cases} \tag{2}$$

Similar to the first-period in the asymmetric subgame, in the symmetric subgame, demand is *more* elastic when consumers are sophisticated than when they are myopic.[32] If $\alpha^1 \leq 0.5$, after having visited firm A in the first period, the indifferent consumer buys at firm A in the second period at an individual price $p_A^{2,S}\left(\alpha^1\right) = t\left(1 - 2\alpha^1\right)$. If instead she purchases at firm B in the first period, firm A does not learn her preferences, and in the second period the indifferent consumer buys at firm A at the uniform price $p_A^{2,S}\left(\alpha^1\right) = t\left(1 - 2\alpha^1\right)/2$. Both prices decrease in α^1, but the discriminatory price decreases more because it is targeted at the indifferent consumer

[31] One could wonder why does not firm A realize smaller profits over two periods compared to firm B for any $\delta \gtrapprox 0.86$ as it does not serve any consumers in the first period and, hence, does not have any data advantage in the next period. The reason is that despite the absence of customer data, firm A gets higher profits in the second period than firm B, because it takes the role of a price follower in the asymmetric subgame.

[32] This result is different from Fudenberg and Tirole (2000), where with a uniform distribution of consumer preferences and sophisticated consumers first-period demand is *less* elastic compared to the situation, where price discrimination in the second period is banned (in the latter case first-period demand is the same as in the case with myopic consumers in our analysis). In Fudenberg and Tirole the indifferent consumer of the first period switches in the second period (provided firms' market shares are not very different). Assume that the address of the indifferent consumer moves closer to firm B. Then after a purchase at firm A in the first period, the indifferent consumer will buy at firm B in the second period at a *higher* price, because first-period consumers of firm A become on average more loyal to firm B in that case. In contrast, in our model after having bought at firm A in the first period, the indifferent consumer will choose the same firm in the second period at a *lower* price, because she becomes less loyal to it. This difference makes first-period demand in Fudenberg and Tirole less responsive to price changes than in the symmetric subgame with sophisticated consumers in our model.

directly. Hence, the difference between the two prices becomes smaller, and more consumers switch to firm A in case of a price reduction compared to the case of myopic consumers who do not take into account future prices in the first period. In the following lemma we state the equilibrium in the symmetric subgame when consumers are sophisticated.

Lemma 8. *(First period. Symmetric subgame. Sophisticated consumers.) Assume that both firms hold targeting technology and consumers are sophisticated. Two asymmetric equilibria exist, where firm i charges a higher price than firm j: $p_{i,s}^{1,S}(\delta) = t\left(24 - 26\delta + 5\delta^2\right)/(24 - 10\delta)$ and $p_{j,s}^{1,S}(\delta) = t\left(24 - 30\delta + 7\delta^2\right)/(24 - 10\delta)$, $i, j = A, B$ and $i \neq j$. Firm i serves less consumers, precisely $\alpha_{i,s}^{1,S}(\delta) = (12 - 7\delta)/(24 - 10\delta)$, and realizes lower profits. Over two periods firms' profits are smaller than in the case where neither firm obtains targeting technology.*

As we know from Lemma 2, each firm's second-period profit increases in its first period market share, which corresponds to the amount of data collected on consumers. Similar to the symmetric subgame with myopic consumers, each firm has then an incentive to reduce its first-period price to obtain more data. However, with sophisticated consumers firms face a more elastic demand in the first period leading to a more intense competition then. As a result, prices are lower in the first period, and so are profits over two periods compared to the case of myopic consumers. Finally, the following proposition characterizes equilibrium incentives to obtain targeting technology when consumers are sophisticated. The subscript "s" refers to the equilibrium values with sophisticated consumers.

Proposition 2. *(Sophisticated consumers. Investment incentives.) If consumers are sophisticated, there exists the unique equilibrium (in dominant strategies), where neither firm invests in targeting technology.*

While with myopic consumers one of the firms obtains targeting technology in equilibrium, when consumers are sophisticated investment incentives vanish. In the latter case neither firm has a unilateral incentive to invest, because the value of data deteriorates as consumers anticipate that it will be used for price discrimination in the second period and avoid the firm with technology accordingly. Similarly, a firm has no incentive to invest if the rival does so. With sophisticated consumers investment incentives in that case are even weaker than with myopic consumers, because demand is more elastic then, which intensifies first-period competition. The intuition for our results is similar to the one, which explains how a monopolist's profits over two periods change depending on its ability to recognize returning customers (see Fudenberg and

Villas-Boas, 2006). Monopoly profits increase when consumers are myopic and decrease with sophisticated consumers. In the latter case the monopolist faces a lower demand in the first period as some consumers postpone their purchases to buy at a lower price in the future. Then if the monopolist could choose whether to recognize consumers, it would prefer to (not to) do that when consumers are myopic (sophisticated). Similarly, in our model in equilibrium a firm invests in targeting technology if consumers are myopic and does not invest with sophisticated consumers.

5.3 Comparison of Equilibria with Myopic and Sophisticated Consumers

In the following corollary we compare equilibrium profits and welfare in the cases of myopic and sophisticated consumers using the results of Propositions 1 and 2, respectively.[33]

Corollary 1. *(Comparison: Myopic vs. sophisticated consumers.) Compared to the case of sophisticated consumers, when consumers are myopic:*
i) discounted industry profits over two periods are lower,
ii) discounted social welfare over two periods is lower,
iii) consumers enjoy higher discounted surplus over two periods if $\delta \gtrapprox 0.9$ and lower otherwise.

It is well known in the literature on competitive price discrimination that the ability to target customers may lead to a prisoners' dilemma (see, for instance, Thisse and Vives, 1988). In our model firms avoid it: In equilibrium at most one firm invests in obtaining the technology that would allow price discrimination, and this happens only in the case with myopic consumers. In this asymmetric subgame, the non-investing firm foregoes the opportunity to learn the preferences of its customers but benefits from softer competition in both periods. Firm A, in contrast, chooses to invest in targeting technology, if consumers are myopic. While it is individually better-off, in the spirit of Thisse and Vives joint profits over two periods decrease compared to the no-investment case. With sophisticated consumers the unilateral incentives to invest vanish too. In case of investment the profits of firm A in the first period would be too low, because consumers would respond with demand reduction in this period. As a result, surprisingly, firms jointly are better off when consumers are sophisticated.

In each period, social welfare is lower when consumers are myopic, because the asymmetric distribution of consumers due to the asymmetric investment decisions causes allocative ineffi-

[33] The critical discount factor is a rounded value, with $\left(3\sqrt{69}-15\right)/11 \approx 0.9$.

ciency. In the first period some loyal consumers of firm A buy at firm B, because their otherwise preferred firm charges a relatively high price to keep a low market share in order to soften future competition. In the second period in turn some loyal consumers of firm B end up with firm A, because customer data enables the latter to attract them with targeted offers.

Over two periods myopic consumers pay less than sophisticated consumers but at the same time have to bear higher transport costs. The first effect dominates if the discount factor is sufficiently large ($\delta \gtrapprox 0.9$), in which case consumers enjoy a higher surplus when they are myopic. To see why, consider the (asymmetric) equilibrium when consumers are myopic. As shown in Table 1, joint profits in the first period decrease in the discount factor, because in that case firms put more weight on second-period profits and distort first-period prices more. Although this leads to a lower first-period market share of firm A and, hence, to higher transport costs, consumer surplus in that period increases due to lower prices. With a smaller first-period market share of firm A, in the second period firm B prices softer, which results in higher profits for each firm. In contrast, consumer transport costs decrease, because firm A gains little customer data and attracts only a few loyal consumers of the rival in the second period. Overall, with an increase in δ, consumer surplus in the second period decreases because of higher payments to the firms. When δ is large enough, the gains in consumer surplus in the first period offset the losses in the second period, and over two periods myopic consumers enjoy a higher surplus than sophisticated consumers.

Our results imply that if the discount factor is large enough ($\delta \gtrapprox 0.9$), there is a conflict between the maximization of consumer surplus and social welfare. While social welfare is always higher in the equilibrium with sophisticated consumers where no investment in targeting technology takes place, consumers may be better off when they are myopic and one of the firms invests. This has important consequences for consumer policy. A policy intervention aiming at the maximization of social welfare should either educate consumers or prohibit customer targeting. However, both policies reduce consumer surplus.

We next analyze firms' incentives to educate consumers by informing them about the use of their data for targeted pricing in the future. We assume that initially consumers are myopic and introduce Period 0, in which firms decide simultaneously and independently whether to educate consumers at a fixed cost $c \geq 0$. Consumers become sophisticated if at least one of the firms educates them. We relax the assumption that firm A is the firm, which acquires the technology

Table 1: Comparison of the Equilibria in the Cases of Myopic and Sophisticated Consumers

	Myopic consumers $T=1$	$T=2$		*Comparison* $T=1$	$T=2$
$\partial\Pi^T_{A,m}/\partial\delta$	<0	>0	$\Pi^T_{A,m}-\Pi^T_{A,s}$	<0	>0
$\partial\Pi^T_{B,m}/\partial\delta$	<0	>0	$\Pi^T_{B,m}-\Pi^T_{B,s}$	<0	<0
$\partial\left(\Pi^T_{A,m}+\Pi^T_{B,m}\right)/\partial\delta$	<0	>0	$\sum\limits_i\Pi^T_{i,m}-\sum\limits_i\Pi^T_{i,s}$	<0	>0
$\partial SW^T_m/\partial\delta$	<0	>0	$\Pi^{1+2}_{A,m}-\Pi^{1+2}_{A,s}$	>0	
$\partial CS^T_m/\partial\delta$	>0	<0	$\Pi^{1+2}_{B,m}-\Pi^{1+2}_{B,s}$	<0	
$\alpha^T_m(\delta)-1/2$	<0	>0	$\sum\limits_i\Pi^{1+2}_{i,m}-\sum\limits_i\Pi^{1+2}_{i,s}$	<0	
$\partial\left\|2\alpha^T_m(\delta)-1\right\|/\partial\delta$	>0	<0	$CS^T_m-CS^T_s$	>0	<0
			$CS^{1+2}_m-CS^{1+2}_s$	>0 if $\delta\gtrapprox 0.9$	
			$SW^T_m-SW^T_s$	<0	<0
			$SW^{1+2}_m-SW^{1+2}_s$	<0	

in the asymmetric equilibrium when consumers are myopic. We assume instead that it is firm A with probability p and with probability $1-p$ it is firm B, while p is a random variable uniformly distributed on the interval $[0,1]$. In Period 0 firms make investment choices after observing the realization of probability p. Table 2 presents the discounted sum of firms' profits over two periods depending on their decisions. We search for a subgame-perfect Nash equilibrium. The following proposition summarizes our results.

Table 2: Profits over Two Periods Depending on the Decision to Educate Consumers

		Firm B Educate	Firm B Not Educate
Firm A	Educate	$\frac{t(1+\delta)}{2}-c$; $\frac{t(1+\delta)}{2}-c$	$\frac{t(1+\delta)}{2}-c$; $\frac{t(1+\delta)}{2}$
	Not Educate	$\frac{t(1+\delta)}{2}$; $\frac{t(1+\delta)}{2}-c$	$f(p)$; $g(p)$

Note: $f(p):=p\Pi^{1+2}_{A,m}(\delta)+(1-p)\,\Pi^{1+2}_{B,m}(\delta)$ and $g(p):=(1-p)\,\Pi^{1+2}_{A,m}(\delta)+p\Pi^{1+2}_{B,m}(\delta)$, where $\Pi^{1+2}_{A,m}(\delta)$ and $\Pi^{1+2}_{B,m}(\delta)$ are stated in the proof of Proposition 1.

Proposition 3. *(Incentives to educate myopic consumers.) Assume that consumers are initially myopic. Depending on the education cost c, the following equilibria emerge:*

i) If costs are low ($c\le\underline{c}$, $\underline{c}>0$), then consumers will be educated with probability 1.

ii) If costs are moderate ($\underline{c}<c\le\overline{c}$), then there is a positive probability that consumers will remain myopic. This probability increases in c.

iii) If costs are high ($c>\overline{c}$), then consumers will not be educated with probability 1.

Proposition 3 shows that if the costs of educating consumers are sufficiently low (high), then consumers become sophisticated (remain myopic) independently of the realization of probability p. If education costs are moderate, then depending on probability p, consumers will be either myopic or sophisticated. In Gabaix and Laibson (2006) the shrouded prices equilibrium where firms hide high add-on prices is sustained because firms do not have an incentive to educate myopic consumers. If a firm does so, consumers learn how to exploit existing prices in the market and prefer the shrouding rival because of its low base-good price. We in contrast argue that in a comparable environment with $c = 0$, consumers are educated to become sophisticated with certainty, which prevents the individually profitable investment in targeting technology triggering intense competition. While firms' choices are efficient from a social welfare perspective and also improve industry profits through weakening competition, consumers are worse off if the discount factor is sufficiently high ($\delta \gtrapprox 0.9$).

6 Investment Incentives when Firms Hold Tracking Technology

In the preceding analysis we assumed that firms cannot identify former customers in the second period unless they invested in *targeting technology*. In this extension we assume that firms start out with a *tracking technology* that allows them to recognize past customers (but not know their exact preferences) and practice behavior-based price discrimination (BBPD) in the second period. This assumption is realistic in some industries. For example, when a retail loyalty program is in place but without meaningful data analytics.[34],[35] We analyze whether firms would additionally acquire *targeting technology* that provides full information on the brand preferences of former customers and allows first-degree price discrimination among them. In the following proposition we summarize our results on incentives to invest in *targeting technology* and to educate consumers when firms start out with a *tracking technology*.

Proposition 4. *(Behavior-based price discrimination. Investment incentives, welfare and incentives to educate consumers.) Assume that firms initially hold tracking technology. Then the following results hold.*

i) Regardless whether consumers are myopic or sophisticated, firms do not obtain targeting technology in equilibrium.

[34] See, for example, Mony (2017) on the interaction between loyalty programmes and data analytics.

[35] The proof of Proposition 4 and of all the results, on which this proposition is based, are provided in the Online Appendix. In the notation of Proposition 4 superscript "D" stays for "discrimination" and denotes the case of BBPD.

ii) If consumers are initially myopic and firms can educate them, then firms choose to do so in equilibrium. This makes consumers worse off, while social welfare remains unchanged.

When firms start out with a tracking technology, they prefer not to obtain targeting technology in equilibrium both with myopic and sophisticated consumers. Nevertheless, consumers sophistication is crucial for profits, which are higher when consumers foresee future use of customer data driving firms' incentives to educate them. The reason is that consumer demand is less elastic with sophisticated consumers. In the latter case the indifferent consumer correctly expects that in the second period she will switch to the other firm (if first-period market shares are not too different) whose price is higher the closer is the address of the indifferent consumer to its own location. Then any price reduction in the first period allows a firm to attract less consumers if they anticipate this negative effect of a larger market share on the prices they will pay in the second period. Less elastic demand yields higher first-period prices with sophisticated consumers: $p_{i,s}^{1,D} = t(3+\delta)/3 > p_{i,m}^{1,D} = t$.[36] In the second period firms realize equal profits irrespective of consumer sophistication, because in both cases each firm serves half of the market in the first period. Overall, firms end up with lower profits when consumers are myopic.

Comparing Propositions 1 and 4 we conclude that in the case of myopic consumers firms' incentives to obtain targeting technology depend on whether they already hold a tracking technology. When consumers are myopic, in equilibrium one of the firms invests in targeting technology only if firms are not able to recognize their past customers. The reason is that in the asymmetric subgame the investing firm (A) is forced to charge (weakly) lower prices in the second period when firm B can track consumers compared to the case when it can not. In the absence of the ability to recognize former customers, firm B charges a uniform price in the second period. This price is relatively high, because firm B has to trade-off attracting consumers on the rival's turf with extracting rents on the own turf. In contrast, when firm B can discriminate based on consumer behavior, it prices aggressively to consumers on the rival's turf, which creates a downward pressure for firm A's prices and profits. Although first-period profits of firm A are higher in the asymmetric subgame with tracking technology, total profits are lower due to intense competition of the second period. This renders investment into targeting technology unprofitable when firms can track consumers. The comparison of Propositions 2 and 4 reveals that with sophisticated consumers incentives to invest into targeting technology do not depend on the

[36] The equilibrium prices $p_{i,s}^{1,D}$ and $p_{i,m}^{1,D}$ are derived in Lemmas A6 and A2 of the Online Appendix, respectively.

ability to discriminate based on consumer behavior: Firms do not invest in either case. The reason is that tracking technology provides some customer data, which decreases the incentives to acquire more. This extension supports the key conclusion of our basic analysis, namely that firms are able to avoid the famous prisoners' dilemma of competition under price discrimination when they can decide on the ability to collect customer data.

We conclude that firms always choose to educate consumers in equilibrium to weaken competition. As Propositions 3 and 4 show, this result does not depend on their ability to discriminate among consumers based on previous purchase behavior. With BBPD in a subgame where neither firm invests in targeting technology, profits are higher when consumers are sophisticated. This happens because sophisticated consumers anticipate high prices in the second period from the firm at which they bought in the first period. As a result, they become less responsive to price reductions in the first period, which makes their demand less elastic, weakens competition and increases first-period prices and profits. Second-period profits are same with both myopic and sophisticated consumers as in the first period firms share the market equally in both cases. Overall the discounted sum of profits over two periods is then higher with sophisticated consumers.

7 Discussion

In this section we discuss the robustness of the derived results to the assumptions of our model. Due to space considerations we restrict this discussion to our main analysis, where without investment in targeting technology firms cannot identify past consumers in the second period.

Heterogeneous consumers. We considered two important limiting cases with all consumers being either myopic or sophisticated. A more general approach would require having both types of consumers simultaneously. Let $\lambda \in [0, 1]$ be the share of sophisticated consumers. If we take demand of the first period (in either symmetric or asymmetric subgame) with all consumers being sophisticated as a starting point, then reducing their share to λ is equivalent to reducing the discount factor of consumers by factor λ, to $\lambda\delta$.[37] Intuitively, when less consumers care about future prices, on average customers discount the future more. Similar to the conclusions of our main analysis, for any λ in the symmetric subgame two equilibria emerge, where a firm with a

[37] The results of our preliminary analysis are available from the authors upon request.

higher price in the first period serves less consumers then.[38] In the asymmetric subgame there exists a critical value of λ, such that below (above) that value the equilibrium of the first period resembles that in the case when all consumers are myopic (sophisticated). In the former case firm A endowed with targeting technology charges a positive price and serves some consumers independently of the discount factor (compare with Lemma 3). In the latter case, when the discount factor takes intermediate values, firm A has to reduce its equilibrium price to zero in the first period, and when δ becomes large enough, firm A does not serve any consumers then (compare with Lemma 6). Based on these results, we expect that there should exist a critical share λ, below which one of the firms invests into targeting technology in equilibrium (as in the case of all consumers being myopic) and above which none of the firms invests in equilibrium (as in the case of all consumers being sophisticated).

Costly targeting. We assumed that once a firm holds targeting technology, it can offer personal discounts at no cost. In practice, designing and distributing individual coupons is likely to be costly. Shaffer and Zhang (2002) consider a Hotelling model, where two firms have perfect data about the preferences of all consumers in the market and can target any consumer with a personal discount (to a regular price) at cost $z \geq 0$. They show that compared to the case $z = 0$, positive targeting costs weaken competition and imply higher profits because firms discriminate less.[39] Based on this intuition, we expect that introducing positive costs of personalized pricing into our model should strengthen the incentives of firms to acquire targeting technology when consumers are myopic. This is likely to happen, because a firm with targeting technology will send less individual offers in the second period implying weaker competition and higher profits. As a result, acquiring targeting technology should become more attractive. However, we do not expect investment incentives to strengthen when consumers are sophisticated, because these will reduce demand in the first period in response to higher future payments. We therefore believe that introducing positive targeting costs should confirm one of our main results that firms are more likely to end up holding targeting technology when consumers are myopic.

[38] Both equilibrium prices decrease in λ, because when the share of sophisticated consumers increases, consumer demand in the first period becomes more elastic, which intensifies competition.

[39] To make the results of Shaffer and Zhang applicable to our model, consider a special case of their analysis where both firms enjoy equal consumer loyalties (precisely, let $l_A = l_B = t$, with l_i, $i = A, B$, being the minimum price differential necessary to induce a consumer to purchase her less preferred brand). Then starting from a situation with zero targeting costs, where each firm's profit is $t/4$, with an increase in z (up to the level $z = t$), a firm's profit goes up to $t/4 + z^2/(4t)$ and it is higher the larger are the costs z. If targeting costs increase even further ($z > t$), then none of the firms makes use of customer data and refrains from sending personal discounts, in which case profits are $t/2$.

Different discount factors for firms and consumers. In our analysis we assumed that both firms and consumers have the same discount factor. An interesting question is how the incentives to acquire targeting technology would develop if firms and consumers had different discount factors. Allowing myopic consumers essentially corresponds to assuming a different consumer discount factor than the one firms use. In that case, firms discount future profits but consumers ignore future surplus. We know that in this case only one firm acquires targeting technology in equilibrium for any firm discount factor. Introducing a positive consumer discount factor should make consumer demand more elastic in the first period, intensify competition and weaken investment incentives. At the same time, from the analysis with sophisticated consumers we know that if consumer discount factor is as high as that used by firms, investment incentives completely vanish. Then we can expect at most one of the firms to acquire targeting technology in equilibrium, provided the discount factor of consumers is substantially smaller than that of the firms. This result would support one of the main conclusions of our analysis that it emerges rare that firms invest in targeting technology.

8 Conclusions

In this article we consider an industry where firms can invest in *targeting technology*, which allows to collect data on the brand preferences of their past customers and send targeted offers to them in the future. We derive three main insights. *First*, equilibrium investment incentives into such a technology are weak. In particular, only one firm acquires *targeting technology* in equilibrium and only if consumers are myopic and/or firms are not able to collect some data through simply tracking their customers. Endogenizing firms' ability to collect consumer information reduces the prisoners' dilemma that arises under competitive price discrimination, which can even completely vanish when none of the firms invests in equilibrium. *Second*, consumers can be better off being myopic and ignoring firms' ability to collect and use customer data for price discrimination. In this case one of the firms invests in *targeting technology*, which intensifies the overall competition and reduces consumer payments. *Third*, to avoid the latter outcome and make individual investment into *targeting technology* unprofitable, firms always prefer to educate consumers and make them learn about their ability to collect and analyze customer data for personalized pricing provided by this technology. Requiring from firms to inform their customers about the intent to use data for future pricing may be harmful for consumers.

Appendix

In this Appendix we provide the proofs of Propositions 1-3. The other proofs can be found in the Online Appendix.

Proof of Proposition 1. We start with the unilateral incentives to invest. Assume that firm B does not invest. If firm A does not invest either, over two periods it realizes the profit $\Pi_{A}^{1+2}(\delta) = t(1+\delta)/2$. If it invests, it gets

$$\Pi_{A,m}^{1+2,As}(\delta) = \frac{t\left(79\delta^3+710\delta^2+2208\delta+1152\right)}{4(5\delta+24)^2}.$$

For any δ we have

$$\Pi_{A,m}^{1+2,As}(\delta) - \Pi_{A}^{1+2}(\delta) = \frac{t\delta\left(29\delta^2+180\delta+576\right)}{4(5\delta+24)^2} > 0,$$

such that firm A always invests.

Assume next that firm A invests. If firm B does not invest, then over two periods it realizes the profit

$$\Pi_{B,m}^{1+2,As}(\delta) = \frac{t\left(-12\delta^3+85\delta^2+528\delta+576\right)}{2(5\delta+24)^2}.$$

If firm B invests, then the profit is

$$\Pi_{i,m}^{1+2,S}(\delta) = \frac{t\left(\delta^3+2\delta^2+96\delta+288\right)}{4(\delta+12)^2} \text{ or } \Pi_{j,m}^{1+2,S}(\delta) = \frac{t\left(-\delta^3+3\delta^2+72\delta+144\right)}{2(\delta+12)^2},$$

depending on the equilibrium. For any δ it holds $\max\left\{\Pi_{i,m}^{1+2,S}(\delta), \Pi_{j,m}^{1+2,S}(\delta)\right\} = \Pi_{j,m}^{1+2,S}(\delta)$. We get that for any δ,

$$\Pi_{B,m}^{1+2,As}(\delta) - \Pi_{j,m}^{1+2,S}(\delta) = \frac{t\delta\left(13\delta^4-38\delta^3-1104\delta^2+2880\delta+13\,824\right)}{2\left(5\delta^2+84\delta+288\right)^2} > 0,$$

such that firm B does not invest. Combining the incentives of firms A and B to invest we conclude that there are two asymmetric equilibria where only one of the firms invests.

The comparison shows that

$$\Pi_{A,m}^{1+2,As}(\delta) + \Pi_{B,m}^{1+2,As}(\delta) - t(1+\delta) = -\frac{45t\delta^2(\delta+4)}{4(5\delta+24)^2} < 0 \text{ for any } \delta,$$

such that total industry profits are lower compared to the case, where none of the firms holds the technology.

The equilibrium social welfare over two periods is

$$\begin{aligned} SW_m^{1+2}(\delta) &= v(1+\delta) - t \quad \int_0^{\frac{24-\delta}{10\delta+48}} x dx - t\int_{\frac{24-\delta}{10\delta+48}}^{1} (1-x) dx - \delta t \int_0^{\frac{3\delta+18}{5\delta+24}} x dx - \delta t \int_{\frac{3\delta+18}{5\delta+24}}^{1} (1-x) dx \\ &= \qquad v(1+\delta) - \frac{t\left(26\delta^3+325\delta^2+960\delta+576\right)}{4(5\delta+24)^2}. \end{aligned}$$

Consumer surplus is

$$CS_m^{1+2}(\delta) = SW_m^{1+2}(\delta) - \Pi_A^{1+2,As}(\delta) - \Pi_B^{1+2,As}(\delta) = v(1+\delta) - \frac{t\left(81\delta^3+1205\delta^2+4224\delta+2880\right)}{4(5\delta+24)^2}.$$

When none of the firms holds the technology, $SW^{1+2}(\delta) = (1+\delta)\left[v - 2t\int_0^{1/2} x dx\right] = (1+\delta)(v - t/4)$ and $CS^{1+2}(\delta) = SW^{1+2}(\delta) - t(1+\delta) = (1+\delta)(v - 5t/4)$. The comparison shows that

$$SW_m^{1+2}(\delta) - SW^{1+2}(\delta) = -\frac{t\delta\left(\delta^2+60\delta+144\right)}{4(5\delta+24)^2} < 0 \text{ and } CS_m^{1+2}(\delta) - CS^{1+2}(\delta) = \frac{t\delta\left(11\delta^2+30\delta-36\right)}{(5\delta+24)^2},$$

which is positive if $\delta > \left(3\sqrt{69} - 15\right)/11 \approx 0.9$. *Q.E.D.*

Proof of Proposition 2. We first analyze the unilateral incentives of a firm to invest. Assume that firm B does not invest. If firm A does not invest either, then over two periods it realizes the profit $\Pi_A^{1+2}(\delta) = t(1+\delta)/2$. If firm A does invest, then

$$\Pi_{A,s}^{1+2,As}(\delta) = \frac{t\left(395\delta^3-404\delta^2-1536\delta+2304\right)}{8(13\delta-24)^2} \text{ if } \delta \leq \frac{70-2\sqrt{721}}{21}.$$

We get

$$\Pi_{A,s}^{1+2,As}(\delta) - \Pi_A^{1+2}(\delta) = \frac{-t\delta\left(281\delta^2-1416\delta+1344\right)}{8(13\delta-24)^2} < 0 \text{ for any } \delta,$$

such that firm A does not invest.

$$\Pi_{A,s}^{1+2,As}(\delta) = \frac{t\delta\left(833\delta^2-2408\delta+1552\right)}{1568\delta^2-3584\delta+2048} \text{ if } \frac{70-2\sqrt{721}}{21} < \delta < \frac{6}{7}.$$

We have

$$\Pi_{A,s}^{1+2,As}(\delta) - \Pi_A^{1+2}(\delta) = \frac{t\left(49\delta^3-1400\delta^2+2320\delta-1024\right)}{32(7\delta-8)^2} < 0 \text{ for any } \delta,$$

such that firm A does not invest either. If $\delta \geq 6/7$, then $\Pi_{A,s}^{1+2,As}(\delta) = 25\delta t/32$. We get

$\Pi_{A,s}^{1+2,As}(\delta) - \Pi_{A}^{1+2}(\delta) = (9\delta - 16)/32 < 0$ for any δ, such that firm A does not invest either. We conclude that there are no unilateral incentives to invest when consumers are sophisticated.

We next assume that firm A invests and analyze the incentives of firm B to invest too. Consider first $\delta \leq (70 - 2\sqrt{721})/21$. If firm B does not invest, its profit is

$$\Pi_{B,s}^{1+2,As}(\delta) = \frac{t\left(53\delta^3 + 228\delta^2 - 2304\delta + 2304\right)}{8(13\delta - 24)^2}.$$

If firm B invests, then its profit is either

$$\Pi_{i,s}^{1+2,S}(\delta) = \frac{-t\left(6\delta^3 - 61\delta^2 + 168\delta - 144\right)}{2(5\delta - 12)^2} \text{ or } \Pi_{j,s}^{1+2,S}(\delta) = -\frac{t\left(5\delta^3 - 78\delta^2 + 288\delta - 288\right)}{4(5\delta - 12)^2}$$

depending on the equilibrium. For any δ it holds that $\max\left\{\Pi_{i,s}^{1+2,S}(\delta), \Pi_{j,s}^{1+2,S}(\delta)\right\} = \Pi_{j,s}^{1+2,S}(\delta)$. We get that

$$\Pi_{j,s}^{1+2,S}(\delta) - \Pi_{B,s}^{1+2,As}(\delta) = -\frac{9\delta t\left(335\delta^4 - 3696\delta^3 + 13\,680\delta^2 - 19\,968\delta + 9216\right)}{8\left(65\delta^2 - 276\delta + 288\right)^2} < 0 \text{ for any } \delta \leq \frac{70 - 2\sqrt{721}}{21},$$

such that firm B does not invest. Consider now $(70 - 2\sqrt{721})/21 < \delta < 6/7$.

$$\Pi_{B}^{1+2,As} = \frac{t\left(-7\delta^2 + 8\delta + 16\right)}{16(8 - 7\delta)}$$

if firm B does not invest. We have

$$\Pi_{j,s}^{1+2,S}(\delta) - \Pi_{B,s}^{1+2,As}(\delta) = \frac{t\left(315\delta^4 - 3384\delta^3 + 12\,128\delta^2 - 16\,512\delta + 6912\right)}{16(8 - 7\delta)(5\delta - 12)^2} < 0 \text{ for any } \frac{70 - 2\sqrt{721}}{21} < \delta < \frac{6}{7},$$

such that firm B does not invest either. Assume finally that $\delta \geq 6/7$. If firm B does not invest, then $\Pi_{B,s}^{1+2,As}(\delta) = t(29\delta - 16)/16$. We get

$$\Pi_{j,s}^{1+2,S}(\delta) - \Pi_{B,s}^{1+2,As}(\delta) = -\frac{t\left(745\delta^3 - 4192\delta^2 + 7248\delta - 3456\right)}{16(5\delta - 12)^2} < 0 \text{ for any } \delta \geq \frac{6}{7},$$

such that firm B does not invest either. We conclude that for any δ firm B does not invest given that the rival invests.

Combining the optimal strategies of firms A and B we conclude that there is the unique equilibrium (in dominant strategies), where none of the firms invests. Then in each period each firm charges the price t and serves half of consumers. Over two periods firms realize profits

$\Pi_{i,s}^{1+2}(\delta) = t(1+\delta)/2$ $(i = A, B)$, and social welfare and consumer surplus are

$$\tfrac{SW_s^{1+2}(\delta)}{1+\delta} = v - 2t\int_0^{1/2} x dx = v - \tfrac{t}{4} \text{ and } \tfrac{CS_s^{1+2}(\delta)}{1+\delta} = \tfrac{SW_s^{1+2}(\delta)}{1+\delta} - t = v - \tfrac{5t}{4},$$

respectively. *Q.E.D.*

Proof of Proposition 3. Remember that $\Pi_{A,m}^{1+2}(\delta) > t(1+\delta)/2 > \Pi_{B,m}^{1+2}(\delta)$. We introduce the functions $f(p) := p\Pi_{A,m}^{1+2}(\delta) + (1-p)\Pi_{B,m}^{1+2}(\delta)$ and $g(p) := (1-p)\Pi_{A,m}^{1+2}(\delta) + p\Pi_{B,m}^{1+2}(\delta)$. If firm B (A) educates consumers, then firm A (B) chooses not to do that. Assume now that firm B does not educate consumers. Then firm A prefers to educate if $p \leq p_A(c)$ and not educate otherwise, where $p_A(c)$ is such that $f(p_A(c)) = t(1+\delta)/2 - c$. If firm A does not educate, then firm B chooses to educate if $p \geq p_B(c)$ and not educate otherwise, where $p_B(c)$ is such that $g(p_B(c)) = t(1+\delta)/2 - c$.

Note that for any c it holds that $p_A(c) < 1$ and $p_B(c) > 0$. If $c > \overline{c} := t(1+\delta)/2 - \Pi_{B,m}^{1+2}(\delta) > 0$, then $p_A(c) < 0$ and $p_B(c) > 1$, with the opposite inequalities otherwise. The comparison shows that $p_A(c) < p_B(c)$ if $c > \underline{c} := t(1+\delta)/2 - \left[\Pi_{A,m}^{1+2}(\delta) + \Pi_{B,m}^{1+2}(\delta)\right]/2 > 0$, with an opposite inequality otherwise. Note that $\underline{c} < \overline{c}$ always holds. We get then the following equilibria. Consider first $c \leq \underline{c}$. The unique equilibrium exists, where firm A (B) educates consumers if $p < p_B(c)$ ($p > p_A(c)$). If $p_B(c) \leq p \leq p_A(c)$, then two equilibria exist, where one of the firms educates consumers. Hence, for any realization of p, consumers become sophisticated in equilibrium. Consider now $\underline{c} < c \leq \overline{c}$. Different from the previous case, there exists a non-empty interval $p_A(c) < p < p_B(c)$, where none of the firms educates consumers in equilibrium. On the interval $p \leq p_A(c)$ ($p \geq p_B(c)$) the unique equilibrium exists, where firm A (B) educates consumers. Overall, consumers remain myopic in equilibrium with probability $p_B(c) - p_A(c)$, which increases in c. Consider finally $c > \overline{c}$. For any p there is a unique equilibrium, where none of the firms educates consumers and they remain myopic. *Q.E.D.*

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