**Aalto University
School of Economics**

Why do firms collect data on customers? A behavior-based price discrimination approach

Economics

Master's thesis

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2011

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Approved by the Head of the Economics Department ___ / ___ 20_____ and awarded the grade

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Aalto University
School of Economics

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Aalto University   Abstract
School of Economics   December 15, 2011
Master's Thesis
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WHY DO FIRMS COLLECT DATA ON CUSTOMERS? A BEHAVIOR-BASED PRICE
DISCRIMINATION APPROACH

PURPOSE OF THE STUDY

This thesis discusses the collection of customer data and its potential use in
price discrimination. I survey the current literature on behavior-based
price discrimination to understand its implications to firms' profitability.
Focus is given to homogenous, non-durable good duopolies to investigate
the competitive effects of customer recognition. As the objective is to un-
derstand why firms invest in the collection of customer data, welfare analy-
sis is left outside the scope of the thesis.

The thesis also discusses two constraints that may have significant impact
on the firms' ability to discriminate. Firstly, customers' view of fairness
may provoke strong objection against behavior-based pricing. Secondly,
the ability to anonymize or hide true identity creates arbitrage similar to
second-hand markets.

RESULTS

Profitability of behavior-based price discrimination is strongly dependent
on the assumptions of the models. With symmetric information about
symmetric demands, firms are shown to be strictly worse off compared to
uniform price regime. As both firms have unilateral incentive to implement
behavior-based price discrimination, the model represents a classic prison-
er's dilemma.

However, less strict symmetry assumptions enable more diverse outcomes.
This thesis discusses separately the importance of asymmetric demand and
asymmetric information. The aforementioned appears to foster the ability
to generate profitable discrimination, but results are ambiguous and leave
still much to answer. The latter is the most recent field of research in be-
havior-based price discrimination. Again, the results are not conclusive and
there is much to examine. I believe this direction to foster the most fruitful
research in the coming years.

KEYWORDS

Behavior-based price discrimination, customer data, switching cost, brand
preference, loyalty, best response asymmetry, anonymization, fairness

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OSTOHISTORIAAN PERUSTUVA HINTADISKRIMINOINTI ASIAKASTIEDON KERÄÄMISEN PERUSTEENA

TUTKIELMAN TAVOITTEET

Tutkielma käsittelee asiakastiedon keräämistä ostohistoriaan perustuvan hintadiskriminoinnin näkökulmasta. Tutkielma on kirjallisuuskatsaus diskriminoinnin kannattavuudesta yrityksille. Keskityn käsittelemään homogeenisiä, kertakulutushyödykkeitä tuottavia duopoleja asiakastiedon keräämisen kilpailullisten vaikutusten kuvaamiseksi. Tämän vuoksi vaikutukset kuluttajan ylijäämälle sekä kokonaishyvinvoinnille jäävät tutkielman rajauksen ulkopuolelle.

Tutkielma käsittelee lisäksi kahta rajoitetta, jotka ovat potentiaalisesti merkittäviä tämän tyyppisen diskriminoinnin kannattavuudelle. Ensinnäkin tarkastelen reiluuden ja oikeudenmukaisuuden kokemuksen merkitystä hinnoittelun hyväksyttävyydelle. Toisaalta asiakkaiden kyky kätkeytyä luo ostohistoriaan perustuvassa hintadiskriminoinnissa vastaavan arbitraasimahdollisuuden kuin jälkimarkkinoiden olemassaolo.

TULOKSET

Ostohistoriaperusteisen diskriminoinnin kannattavuus yrityksille riippuu ratkaisevasti mallien symmetriaoletuksista. Mikäli yrityksillä oletetaan olevan symmetristä tietoa kysynnän olessa symmetristä, lopputuloksena on klassinen vangin dilemma, jossa yksityisesti kumpikin yritys hyötyy asiakkaiden tunnistamisesta mutta yhdessä yritykset päätyvät epäoptimaaliseen ratkaisuun.

Lieventämällä symmetriavaatimuksia voidaan kuitenkin saavuttaa moninaisempia lopputuloksia, jolloin diskriminointi voi olla myös yhteisesti kannattavaa. Käsittelen erikseen sekä epäsymmetrisen informaation että epäsymmetrisen kysynnän merkitystä diskriminoinnin kannattavuudelle. Kirjallisuus ei ole toistaiseksi saavuttanut yhteisymmärrystä lopputuloksista, joten tällä tutkimuksen saralla on yhä tarvetta lisätutkimukselle. Uskon että hedelmällisin tutkimus löytyy jatkossa erityisesti epäsymmetrisen informaation alueelta.

AVAINSANAT

Ostohistoria, hintadiskriminointi, vaihtokustannus, lojaalius, asymmetrinen paras vastaus, kätkeytyminen

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1 Introduction

Customer recognition is a hot topic in the retail sector at the moment and collection of customer data has become an increasingly common practice among companies. The advances in information technology and the trend of customers becoming less anonymous to firms have opened up vast sets of available customer data. Not only is it currently technically possible to automatize pricing based on various attributes, starting from the time of the day to the clicks a customer makes online, but also customers are more and more willing to share their identities with companies.

The vision for future shopping is rather striking. Take for example the latest Harvard Business Review (12/2011) report on retailing. HBR envisions practices such as automatic customer recognition at the entrance of the store; recommendations in the fitting room based on customer's purchases; and customized offers at the checkout to entice additional sales. According to HBR "using increasingly granular data, from detailed demographics and psychographics to consumers' clickstreams on the web, businesses are starting to create highly customized offers that steer customers to the "right" merchandise or services – at the right time, at the right price, and in the right channel."

The vision HBR paints is definitely not utopia. Customer recognition is already widely spread. Nearly 90% of the Finns own a loyalty card according to the 2011 Eurobarometer on data protection and electronic identity. On top of this, many belong to social communities, such as Foursquares, that encourage people to reveal their identity and preferences to firms. In a recent case of botulism in canned olives, the Finnish data protection authorities gave the retail chain Kesko an exception to look up individual customers who had bought the product. This shows that the retailers already collect information about who bought and what. In other countries the use of customer data for target marketing is already business as usual. For example, the Swedish retail chain Ica openly collects customers' purchase histories and sends monthly, targeted coupons to each customer based on her past purchases.

As customers become increasingly aware of the data collection, this awareness may alter their behavior. According to the 2011 Eurobarometer, the EU citizens are increasingly worried about their purchase histories and behavior being tracked via loyalty and credit cards, both online and offline. Although there are significant differences between countries in the level of anxiety, clear result of the survey is that people want the authorities to control data collection and to protect privacy. This is also highly topical issue. Both the discovery of hidden tracking software Carrier IQ and the Wikileaks' publication of Spy Files have raised concern about widespread data collection from consumers' mobile phones and computers.

Even disregarding the Orwellian feel of the situation, the exposures show that the worry citizens have for privacy is not unfounded. These revelations are certain to affect the way people view relations with firms in the future. They also raise pressure for the governments to protect privacy and monitor data acquisition. Interestingly, this may well serve both consumers and suppliers. If customers fear that their private information is used against them, they might be less inclined to buy which will harm the firms as well (Taylor 2004).

At the same time other constraints have reduced in importance. Most significantly it has become radically cheaper to collect and store data. The cost of storing one gigabyte of data is currently a mere tenth of what it was in 2005 and is expected to drop below one dollar by 2015 (IDC's Digital Universe Study 2011). The declining storage cost enables firms to collect data that was earlier unobtainable due to the high cost. That is to say, the data has always been there but it has not been affordable to collect until recently in larger scale.

We are currently at a stage where there is an abundance of information in the market. Firms are capable of investing in data management systems to utilize the information and at the same time there is a growing concern from the public's side about the use of this data. In this rapidly evolving situation, economists need to be able to evaluate how the availability of customer data affects markets. We also have to estimate who are the ones in need of protection and what is the effi-

cient way to ensure that protection. Even if the vision HBR paints will not be fulfilled to the full extent, this is clearly the direction retail is moving towards. Therefore, we need to be able to predict and evaluate the outcomes and welfare effects of the widespread use of customer data.

Economists also have to be able to estimate the rationality of the investments the firms are making. No firm invests in customer data collection unless there is a profit to be gained from it. There are myriad reasons for firms to collect data. Knowing customers may assist in improving customer service or be utilized in product differentiation. Detailed customer data could also be sold to other firms as Spy Files claim or used for anticompetitive ends such as predatory pricing. Most importantly, firms may want to know more about individual customers in order to price discriminate. The last point is what Harvard Business Review, along with many economists, supports by saying that businesses need to "create highly customized offers -- at the right time, *at the right price*, and in the right channel." This thesis seeks to understand how customer data affects firm's ability to discriminate and what the implications of that discrimination to profitability are.

1.1   Behavior-based price discrimination

Discrimination based on collected customer data about past purchases is called behavior-based price discrimination (Fudenberg and Villas-Boas 2005). In its most simple form, the data is just the knowledge of whether a customer is new or recurring. If all the customers buy at every period, then all new customers must have bought from the rival in the previous period. This enables firms to separate customers to different segments; own and rival's customers.

Behavior-based price discrimination (abbreviated BBPD) enables firms to acquire two kinds of additional profits compared to uniform pricing. Firstly, when a firm learns which customers prefer it tos rival, it can exploit this knowledge by setting a higher price to its own customers due to their higher preference. Thus, BBPD enables the firms to generate "extraction profits" by taking away part of the consumer surplus. Secondly, because the firm can separate own and rival's

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customers, it can set differing price on the rival's market. Since the firm knows that the rival's customers can be lured only with a lower price (due to their lower preference), firms gain "poaching profits" from stealing some of the rival's customers with low introductory offers. These two additional profits make it always optimal for the firm to unilaterally discriminate based on the purchase history.

Because behavior-based price discrimination is based on the firm's ability to segment markets based on some visible attribute (here purchase history) and set different prices to different segments, BBPD is essentially a type of third degree discrimination. Gehrig and Stenbacka (2005) point out that perfect price discrimination is actually the limit BBPD approaches as more and more data is obtained about individual customers. For example an online store, instead of setting up price schemes for just a couple of segments, can identify each individual customer at a time. The store can then set personalized prices depending on the information it has obtained by observing the customers' behavior, thus approaching perfect discrimination. But since implementation of BBPD does not require perfect information, it is more practical to view it as third degree price discrimination.

This thesis introduces the special case of perfect discrimination but otherwise considers behavior-based pricing as a type of third degree price discrimination. For a wider view on discrimination theory, Armstrong (2006) offers an excellent introduction to the recent advances in the field of price discrimination, including behavior-based price discrimination, while Fudenberg and Villas-Boas (2005) conduct a comprehensive review on the literature on BBPD.

Though the possibility to collect and analyze vast sets of customer data is fairly recent, discrimination based on customer information is not fully new to the firms. Especially industries where information about the customers is accrued automatically, as in subscription markets, discrimination based on that knowledge is typical. For example, mobile operators have long offered lower price to rival's customers to induce them to switch. Similarly, in the U.S. Pepsi

and Coca-Cola have offered discount coupons for their own beverage printed on the back of the grocery store receipt for customers who bought the rival's label (Shaffer and Zhang 2000). These two examples require very limited amount of information to generate discriminatory prices. As information increases, discrimination can become more complex. Especially online markets offer excellent opportunities to track customer behavior in real-time and to utilize this information in pricing.

Probably the most famous example about online price discrimination is the webstore Amazon's dynamic pricing experiment in the beginning of the century. Amazon applied a scheme where the webstore quoted different DVD prices for different customers (e.g. Streitfeld 2000). Although denying the discrimination, it seems that Amazon – which records just about everything the customer sees and does on its website – conditioned prices based on the information they had about each individual customer. Unfortunately for Amazon, the customers noticed that removing the cookie that identified them as old customers resulted in significant price cuts for the products. Due to fierce public objection, Amazon was forced to end the practice and refund the customers who had paid the higher prices.

The more complex discrimination gets, the more important it is to understand the incentives and outcomes behind behavior-based discrimination. It also appears that customers are not toothless even when it comes to elaborate pricing schemes. The Amazon example is an excellent illustration of the behavioral constraints the firms may face with behavior-based price discrimination. When customers have strong sense of fairness, the unified protest against unfair pricing may be severe enough to scare the firms off. Furthermore, the revelation of the pricing scheme was due to the customers' ability to anonymize. By deleting cookies from web browsers, the customers were able to hide their identity and reveal the price discrimination. Hence, it is important to also study these constraints under behavior-based discrimination.

1.2 Information

Does it then matter what kind of data firms collect? Firms can obtain basically two kinds of information about customers: vertical and horizontal. Vertical information is based on the customers' preferences for the good, e.g. about quality or quantity. For example, firms would like to recognize customers who prefer high quality from those who care mainly about price and would be therefore willing to buy low quality. Similarly, banks would like to separate the high-risk customers from the low-risk ones. Under vertical information firms react similarly to the information; all banks want to set high interest rates to the high risk customers while offering low rates to the low risk types. Corts (1998) defines this as best-response symmetry.

Horizontal information, on the other hand, differentiates firms from one another. It depicts the brand preference or loyalty the customer has for one, but not for the other firm. For example, customers may for some reason be willing to pay more for Coca-Cola than Pepsi although the contents of the products are essentially the same. From the firm's point of view, the situation is very different from the situation for vertical information. Now all firms want to treat customers differently because they realize that the horizontal preference must be offset somehow. The situation where one firm's strong market is the other firm's weak market is called best-response asymmetry (Corts 1998). While one firm wishes to set high price for one group, the other firm's optimal choice is to price low for the same group.

Interestingly, in competitive setting vertical information loses its relevance if firms share symmetric information. According to Armstrong (2006), vertical information plays no role in pricing decisions among competitive firms. This is quite natural when one considers the content of the information. Because vertical information deals with customers' preferences towards the product, assuming homogenous good means that this type of information cannot differentiate the firms. Customers buy from whichever firm offers the lowest price. If either firm were to know the true valuations of each customer it would not be able to exploit this information because it is still in the other firm's best interest to un-

dercut the higher price. Therefore only information that differentiates firms can be used for discrimination in competitive settings.

The literature about behavior-based pricing therefore discusses horizontal information. This information can be either about brand preference, switching cost or loyalty. Note that the terms are interchangeable. On one hand, switching cost is a measure of brand preference because it represents resistance towards poaching (Shaffer and Zhang 2000). On the other hand, when a customer with high switching costs is resistant to poaching she is said to be loyal to the incumbent firm.

It is, however, necessary to separate information about who is preferred and how much. In this thesis, brand preference is used to indicate binary preference relation: customer likes firm A more than firm B. This is consistent with the terminology used in the early models of BBPD. Loyalty again represents to what extent customer prefers either firm. For a group of customers preferring firm A, some prefer it a lot while others just a bit more than they prefer the rival. The most difficult term to separate is that of switching cost. In order to point out the impact switching cost has on different models, it is first viewed from the same perspective as brand preference. From chapter three onwards switching cost is considered a synonym to loyalty. High switching cost is essentially loyalty because it induces the customer to tolerate larger price discrepancy between the firms.

It also makes a difference whether the firms can obtain private information. If the firm's customers differ in their horizontal preferences and the rival does not know this, the firm may be able to create higher extraction profits without being exposed to more targeted poaching. Thus, it is important to discuss information symmetry between the firms. This has a major impact on the outcomes of the different models. Information becomes asymmetric when only one of the firms is able to recognize customers, or if the purchase history reveals information about loyalty.

1.3   Research question and related topics

Information and demand symmetries have significant effects for the outcomes under behavior-based price discrimination. To understand the implications of data collection I examine different models of BBPD and show that the outcomes differ due to the symmetry assumptions. I introduce first the model of Thisse and Vives to familiarize the concept of customer recognition under perfect discrimination. Thereafter I move on to behavior-based pricing and imperfect horizontal information. I discuss brand preferences following the footsteps of Fudenberg and Tirole (1999) and switching costs following Chen (1997). While the price paths are opposite in these two-period models, the outcomes are identical because both model symmetric information with symmetric demands. Though not explicitly underlined in the papers, the outcomes rely on best response asymmetry.

Moreover, to understand the relevance of information symmetry, I will extent the discussion to include asymmetric information. Under this discussion I point out the importance of firms' ability to create horizontal differentiation. The more differentiated firms are in the customers' eyes, the more profitable discrimination becomes. Under symmetric information more accurate segmentation intensifies competition, but here it makes higher extraction profits possible.

This thesis aims to explain why firms collect customer data and what the implications thereof are to the firms. I thus focus on the applicability of BBPD and survey the literature to see how the current research views the matter. The interest is in homogenous, non-durable goods duopolies under best response asymmetry. Restricting the analysis to this quite constrained area enables to explore the implications in greater detail. Furthermore, there are many interesting industries that fall in to this category: for example subscription markets, like mobile services, and much of the online markets. These industries share common features such as ease of customer recognition, homogeneity of products and relatively low switching costs that assure competitiveness in the markets.

Although behavior-based price discrimination has interesting but ambiguous impacts on consumer surplus and total welfare, I will only point out few robust outcomes and restrict the analysis otherwise to the effects for the firms. In addition, related topics that will not be covered include product innovation (use of customer information on product choices), anticompetitive effects and legal aspects. The latter-mentioned are of course important when considering privacy and the collection of customer data. However, as legal issues are exogenous to firms' decision-making, they are not essential to discrimination as such. For literature about product innovation, see e.g. Fudenberg and Tirole (1998) and Zhang (2011). For an interesting overview of the topic of competitive effects, the Swedish Competition Authority's report (2005) on price discrimination offers excellent reading.

The thesis is constructed as follows: the second chapter discusses behavior-based price discrimination under symmetric information and demand. The third chapter expands this discussion to include asymmetric demands. The fourth chapter then considers information asymmetry between the firms while the fifth discusses constraints that might bind firms that practice behavior-based pricing. The sixth chapter concludes the thesis.

2   Symmetric information and demand

In order to study any economic events, it is necessary to build simplified models. The simplest setting to consider is the one with most symmetry. Therefore this part examines behavior-based price discrimination under symmetric horizontal information and symmetric demand. Symmetric horizontal information in this context refers to the firms' ability to recognize customers' brand preferences towards the firms. Demand symmetry means that both firms face similar groups of customers, although customers themselves can differ in characteristics.

To familiarize the mechanisms at play in behavior-based price discrimination, I first present what happens in a duopoly under perfect information. I first introduce the model of perfect discrimination by Thisse and Vives (1988) following

the notation of Armstrong (2006). After understanding where BBPD stems from, I move on to models of imperfect information. This chapter summarizes the findings in the literature about the situations where firms share imperfect information about symmetric demands.

2.1 Perfect discrimination

The well-known Hotelling model from 1929 formulates two competing firms under horizontal differentiation. The firms produce homogenous goods and serve a market of uniformly distributed customers. Hotelling shows that assuming that the firms can choose their locations on a street both firms would want to locate in the middle to obtain the largest possible market. Therefore, with no customer information, firms' strategy is to minimize horizontal differentiation, in this case the distance between them. Thisse and Vives (1988) utilize this setting to investigate the implications of perfect information with ex-ante differentiated firms.

Assume two firms, A and B, which are located at the opposite ends of a Hotelling line and a uniform distribution of customers. Each customer faces transportation cost from her location (denoted by x) to the firm's location. This means that firm A has cost advantage for half of the customers and B for the other half. The produced good is non-durable and there are no second-hand markets (i.e. no arbitrage). Further, Thisse and Vives model geographical distances. Hence, the transportation cost is the larger the further away the customer is located from the seller. The transportation cost for a specific customer consists of both distance and a common cost parameter that represents the value of the distance (e.g. €/km). In other instances the transportation parameter can measure the choosiness of customers, i.e. how much weight is given to some characteristic. Furthermore, marginal cost is normalized to zero and assumed identical for both firms. Then, the consumer's surplus for buying from firm A is

$$u_A = v - p_A - td_A \qquad (1)$$

where v is the valuation for the good, p_A is the price for firm A, t is the parameter for transportation cost (i.e. how significant the distance is) and d_A is the distance from firm A. Because locations are defined between [0,1], we can denote $d_A = x$ and $d_B = 1 - x$. Thus the customer buys from A if

$$p_A + xt \leq p_B + (1 - x)t . \qquad (2)$$

That is, the less costly transportation is (i.e. the closer to zero the value for parameter t becomes) the more indifferent customers become between the firms. For t = 0, customer disregards distance and buys from firm A if $p_A \leq p_B$. Thisse and Vives restrict the prices to be always below the valuation to ensure each customer buys from either firm. Now assuming that firms know where each customer is located, they can set each customer an individual price in order to extract as much surplus as possible subject to (2).

Thisse and Vives show that price discrimination is dominant strategy for both of the firms in this setting. This follows from the price equation (2). The closer to zero the value for x is the larger the substitute's cost becomes. Thus, it is in firm A's best interest to set the highest price for those customers who are located nearest. The higher transportation cost from B ensures that B cannot compete against prices incrementally below the customer's total cost of buying from B (price plus transportation cost). Under perfect information, Hotelling's result of minimum differentiation breaks: when firms know all about their customers, they refrain from uniform pricing and maximal differentiation becomes optimal. Customers close to the median are offered the lowest prices because price competition increases once total cost for either firm approaches the other. Less differentiation forces firms to compete in prices. Thus the lowest price is offered to the customer with the highest transportation cost, while those with low transportation cost face the highest prices. The price for each customer, depending on her location, is then

$$p_X = (1 - 2x)t \qquad \text{if } x \leq \tfrac{1}{2} \qquad (3)$$
$$p_X = (2x - 1)t \qquad \text{if } x \geq \tfrac{1}{2}$$

Solving both firms' best responses in the uniform price regime, the uniform price would optimally be equal to the transportation parameter t. Compared to the discriminatory prices, all customers are at least as well off under discrimination as they are under uniform pricing (customers at x=0 and x=1 are indifferent).

Figure 1

$P_{unif} = t$

$P=(1-2x)t$ $P=(2x-1)t$

A's market   B's market

Figure 1 illustrates the price paths under discrimination and uniform pricing. On the vertical axis the graph depicts the distance of each customer to the substitute. This is the measure of horizontal differentiation between the firms. Horizontal axis represents the uniform distribution of customers on the Hotelling line, while the lines depict the optimal pricing from equation (3). The graph thus captures the negative effect of personalized pricing. Both firms would get ½t as profit per period under uniform pricing but only ¼t once they target prices based on distance. The outcome is efficient because all the consumers buy from the closest firm. However, due to the intensified competition, surplus simply shifts from the suppliers to the consumers.

Though both firms are clearly better off under uniform pricing, discrimination is unilaterally dominant strategy for both. The situation is a classic prisoner's dilemma, which cannot be undone without cooperation. Note that in this model the firms share symmetric horizontal information. Knowing everything about the market changes the way the firms react. The firms compete head on about each individual customer, not the market as a whole. This leads to the heavily intensified competition and to the prisoner's dilemma outcome. To appreciate the robustness of this result, let us next turn to the realm of imperfect discrimination.

2.2 Brand preference

Being familiar with the results of symmetric information under perfect discrimination, we can move on to the models of behavior-based discrimination. It is worth reminding that the above-discussed model is the limit of behavior-based pricing. As information aggregates, firms are able to price as in Thisse and Vives. However, as perfect discrimination is, and probably will remain, an unfeasible concept, it is more interesting to discuss how imperfect information about customers affects markets. From now on, firms can no longer discriminate individually, only on segment-basis. More precisely, in this section firms only obtain information about the brand preference. In other words, firm learns if the customer likes it more than the rival.

Furthermore, the model of Thisse and Vives is purely static, while majority of the models discussing behavior-based price discrimination are dynamic games. Basic setting is that in the beginning of the first period the firms know nothing about the customers, therefore setting uniform price. Learning happens during the first period purchasing so that in the beginning of the second period the firms can use that information in pricing.

In this section, I introduce two simple models of BBPD under symmetric, horizontal information. First is a two-period duopoly model with continuous preferences by Fudenberg and Tirole (2000) and the second is Chen and Zhang's (2009) model with discrete types.

2.2.1 Continuous preferences

Let us first consider the model of Fudenberg and Tirole (2000). Again, two firms, A and B, are assumed identical in terms of costs and are situated on a Hotelling line. Customer preferences are assumed uniformly distributed along this line similar to Thisse and Vives. There is unit consumption per period, i.e. each customer buys only from one firm at a time. The customers have inherent preference over either of the firms with the median customer being indifferent. The preferences are denoted by $\theta \in [\theta_A, \theta_B]$ and assumed constant over time, while firms' pricing is assumed to be below reservation prices to ensure unit demand

in each period. The parameter θ has the same interpretation as distance in Thisse and Vives, but unlike in their paper, firms cannot identify θ explicitly. Firms will only learn whether the customer has preference for them or not, not how strong of the preference is.

Figure 2 depicts the situation under symmetric information about brand preferences. The presentation is slightly simplified compared to Fudenberg and Tirole. The first period uniform price is set equal to the second period price to own customers whereas in Fudenberg and Tirole the firms have to lower also their second period prices to own customer. Therefore my illustration paints somewhat more optimistic view. But as will be shown soon, this does not affect the overall outcome for firms.

Figure 2

In the first period the firms do not know the customers and they must set uniform price P1 to all. After the first period purchasing is done, the firms learn the relative brand preferences of the customers. Purchase behavior in the first period reveals that the customers who bought from firm A, have θ closer to $θ_A$ and correspondingly for firm B. Note that in this case the firms do not observe the lines depicting the degree of preference (analogous to the price lines in figure 1), they only know on which side of the Hotelling line the individual customers are. Because the firms now know that the customers who bought from the rival have lower preference for their product, the firms' optimal strategy is to set a lower second period price to the rival's customers in order to obtain poaching profits.

Firms can therefore separate two segments and set two different price schemes in the second period: P1 for the own customers and P2 for the rival's customers.

Areas 1, 2 and 3 represent A's profits in the first period from setting the uniform price equal to P1 and serving half of the market. In the second period A maintains price P1 for its own customers while sets poaching price P2 to B's market and wins over area 4 from B. However, since the firms are identical, also B will set poaching price P2 and thus gains the same profit from area 2. Note that A can only keep those first period customers whose preferences are above P2 and gains profit of area 1 from them. Thus A's total profit in the second period is equal to 1+4 while it loses area 2 to B.

But what then happens to area 3 in the second period? Similarly to perfect discrimination, there are now more markets on which to compete. Therefore the customers who switch from A to B and vice versa get the good at a lower price. However, not all of area 3 is shifted to the consumers since part of it is lost due to inefficient switching. To illustrate the welfare loss, consider the marginal switcher; the last person to switch is just indifferent between staying at a higher price and switching for a lower price. That consumer gets the same utility regardless what he does, but the firm selling at the poaching price makes smaller profits due to poaching.

As the above-illustrated figure is simplified for presentational reasons, it does not capture few interesting outcomes that Fudenberg and Tirole calculate in their article. First of all, prices are in fact higher in the first period than they would be under uniform pricing. Secondly, the second period price to own customers is lower than the uniform price would be. The effects of poaching explain the latter result. A bigger price difference between A's price to own customers and B's poaching price for the same group would induce more customers to switch. In order to hang on to these customers, it is in A's interest to minimize the price discrepancy by lowering price to own customers. Fudenberg and Tirole calculate that under uniform distribution of preferences the optimal price for

own customers in the second period is ⅔ and the optimal poaching price is ⅓. This will induce exactly one third of the customers to switch.

The explanation for the higher first period prices is somewhat more complicated. Fudenberg and Tirole reason it as follows: assuming that the customers are far-sighted, they realize in the first period that the rival firm will set a low poaching price for them in the second period. This has a strategic impact for the first period prices. The marginal customer is indifferent between buying today from A at the price P1 and buying tomorrow from B at the poaching price P2. This makes the marginal consumer less price sensitive in the first period. Armstrong (2006) complements that larger discrepancy between the first period price and the poaching price induces more customers to switch. As switching is beneficial for the consumers, they prefer large price difference to smaller one. Thus, customers welcome higher first period prices than they would under uniform pricing. This of course means that if customers are myopic, that is, they do not foresee their purchase today affecting the price tomorrow, the prices in the first period remain at the non-discriminatory level.

Villas-Boas (1999), on the other hand, argues that prices are higher in the first period due to firms' incentives, not the customers'. After all, the larger the firm's market share is in the first period, the smaller its "poaching market" in the second period becomes and thus the potential poaching profits are smaller. Correspondingly, a firm with a small market share has a large pool of customers to poach, resulting in more aggressive poaching. Thus, the more the firm appreciates poaching profits the less it cares about the first period market share. Firms compete less intensively and prices are higher in the first period than they would be under uniform pricing. In either case, the lower prices for the switching customers in the second period increase the total consumer surplus compared to the uniform price regime.

A relevant point to acknowledge in the brand preference models is that preferences are assumed to be known by the customers in the beginning of the first period. Whereas in spatial models, like that of Thisse and Vives, ex ante

preferences make sense, there is no reason why customer would like Coca-Cola over Pepsi before ever testing either product. Hence, these models ignore that the customer needs to test both products to learn her preference. This would definitely change the motives for poaching in a two-period model because some customers would switch just to test the other product. Alternatively, the situation depicted in Fudenberg and Tirole (2000) or Villas-Boas (1999) could be obtained by investing in marketing in order to create ex ante preferences. In this case the cost of marketing would need to be taken into account and preference would no longer be costless for the firms.

While the model of Thisse and Vives showed that welfare just shifts under price discrimination, in dynamic models this holds no longer. Fudenberg and Tirole conclude that BBPD is socially undesirable because the second period poaching causes inefficient switching. That is, while customers choose their most preferred firm in the first period, some of them switch to the firm they like less due to poaching. The increase in consumer utility does not equal to the loss in supplier surplus and therefore behavior-based pricing creates a welfare loss.

Further, note that the negative effect of behavior-based price discrimination arises solely from poaching. Firms are worse off not because they can segment customers, but because they have an incentive to lower prices for the opposite customer segments. Best-response asymmetry generates poaching, which is the harmful mechanism at play, not discrimination as such. Furthermore, because demands are symmetric, i.e. both firms face similar customers, poaching is equally profitable to both firms. The fact that prices need to be cut in all markets is what leads to worse outcomes in the models of full symmetry. With symmetric information, the rival can optimize its poaching price, which in turn forces the incumbent to also set lower price to its own customers to fight back poaching. Both extraction and poaching profits decrease under symmetric information.

2.2.2 Discrete preferences

Using slightly different approach, Chen and Zhang (2009) tackle the dynamic problem of discrete preferences. They assume three types of customers contrary

to uniform distribution. Customers are either loyal to A, loyal to B or indifferent. Demand is symmetric as in the previous models since A and B are assumed to have equal amount of loyal customers.

Chen and Zhang find screening necessary for the firms to gain additional information about the customer types. In order to separate the loyal customers from the indifferent ones, the firms must set high enough prices in the first period to ensure that only the loyal customers buy from them. After all, if also the indifferent customers were to buy from the firm, no information with which to discriminate would be gained about the market. This drives both firms to set higher than uniform regime prices in the first period. The reduced price competition in turn makes both firms better off while reducing consumer surplus. The first period result is in line with the models of symmetric brand preferences by Villas-Boas (1999) and Fudenberg and Tirole (2000).

However, while Villas-Boas and Fudenberg and Tirole excplicitly conclude that firms are worse off under BBPD due to the second period poaching, Chen and Zhang end up in the opposite conclusion. Notably, the model of Chen and Zhang assumes the loyal segment to be fully locked in, which ensures that also the next period profits remain at higher level than in uniform regime (Fudenberg and Villas-Boas 2005). That is to say, the poaching market is deminished because only one segment of the market can be poached, whereas in the previous models all customers could potentially be poached. As previously, because poaching is harmful to the firms, any action that reduces poaching benefits the firms. The extraction profits are also higher than in previous models due to the lock-in yielding profitable discrimination. The nature of Chen and Zhang's model raises the question about whether high switching costs could lead to similar outcome.

2.3 Switching cost

Thus far the models have discussed cases where discrimination is enabled by inherent customer characteristic, such as location or brand preference. Another set of BBPD literature relying on the foundation of Thisse and Vives is that of switching costs. While previously the transportation cost of Thisse and Vives

received the interpretation of preference relation, in switching cost literature the customers are assumed ex ante indifferent between the firms. Transportation cost occurs only in the second period in the form of switching cost.

Switching costs are any costs generated due to changing supplier. They can be monetary costs (e.g. exit fees), psychological cost (e.g. search or learning cost) or costs of losing either achieved benefits (e.g. loyalty discounts) or network gains, such as the knowledge of other users (e.g. leaving Facebook for Google+) (Varian 2001). As earlier noted, switching cost is a measure of brand preference because it represents the resistance to poaching. Therefore switching cost has similar impact on firms' optimal choices as brand preferences and figure 2 applies here as well. However, switching costs create different price dynamics, which will be discussed next.

Chen (1997) was among the first to study the effects of switching costs in behavior-based pricing. The model is essentially the same as the one of Fudenberg and Tirole (2000). The important difference is that the customers do not have inherent preference to either of the firms in the first period. In the second period, however, customers are no longer indifferent because switching supplier would generate a cost. In the brand preference case the customer faces no costs due to switching. Similar to the brand preference models, switching costs are assumed uniformly distributed. That is, some customers have lower and some higher cost of switching but firms only know the expected switching cost.

Because there is no brand preference for either firm, customers buy in the first period from the firm offering the lowest price. With symmetric firms this means that the two firms set equal prices and share the market 50-50. After the first period purchasing is done the existence of switching costs creates a partial lock-in for the customers. Now customers only change supplier if the rival offers price lower than the incumbent's price plus the switching cost.

Once the firm recognizes its customers in the second period, it also knows that these customers endure larger price discrepancy due to the switching cost. On

the other hand, each firm knows that in order to lure the rival's customers, the price must offset the switching cost. Hence, also here own customers are offered a higher price than the rival's customers. Under uniform pricing, switching costs cause second period prices to be higher than the first period prices to all customers. Thus, a market with switching costs faces the same best-response asymmetry as the model for brand preferences.

Chen shows that the existence of exogenous switching costs leads to firms competing intensively in the first period. Since larger customer base in the first period means more locked-in customers, the first period prices drop in fact below the marginal cost in Chen's model. In addition, here the far-sightedness of the customers is irrelevant. Because the key driver for the first period prices is the lock-in effect and not the customers' expectations, price path will be similar even if customer were myopic. Thus, while in the previous discussion about the preference-based models prices decrease over time, in the case of switching costs prices grow over time. The outcome remains the same: the ability to recognize customers makes the firms worse off.

As the rival's incentive to poach is a problem to firms, a possible escape route could be to lock all the customers in for the second period. This would mean imposing high enough switching cost to deter switching. One possible way to achieve this is to offer long-term contracts, as Fudenberg and Tirole (2000) suggest. However, because firms forgo greater extraction profits when they force both low and high switching cost customers to the same contract type, Fudenberg and Tirole find that it is never optimal to offer only long-term contracts. Thus, a fraction of the market buys only short-term contract and poaching occurs in the second period.

Offering long-term and short-term contracts is quite similar to Chen and Zhang's (2009) model of discrete preferences. While both models incorporate captive customers and switchers in the second period, the models differ substantially in the first period dynamics. As already mentioned, in Chen and Zhang the first period prices are high due to screening. In Fudenberg and Tirole, however, custom-

ers are not inherently loyal. Thus, the results differ in the same manner as for the basic brand preference and switching cost models. In the aforementioned the first period price is higher, while in the latter it is lower than under uniform pricing. Because the second period is identical in both models, differences in the first period results determine the overall profitability.

There is also an important difference in the information content. Chen and Zhang assume the firms to know not only brand preferences, but also the degree of preference, i.e. how loyal the customers are. By setting high prices, the firms in fact search for the customers who are closest to them. This is additional information compared to the other BBPD models discussed in this chapter. However, according to the results of Thisse and Vives (1988) firms should not be better off even with more detailed information. Hence, the difference must derive from the rather restrictive assumption of captive customers. While Thisse and Vives consider all the customers to be potential switchers, in Chen and Zhang only one fraction of the market is willing to change supplier. This makes the model similar to the models of addressability (e.g. Esteves 2009) where some customers are unaware of the rival. When part of the customers is captive without this imposing a cost to the firms, BBPD can become profitable.

The results under full symmetry seem to be able to describe the features in subscription markets rather well. The basic assumptions of homogenous good unit demand and full market coverage fit e.g. the mobile service sector well. For example, in Finland mobile operators are at least in theory able to look up each phone number owner and see who subscribe to a rival. However, when more complex information about the customers is collected, the interaction between the customer and the firm grows in importance. The following chapters look in to less restrictive assumptions concerning symmetry and expand the information firms are able to collect. This way, we can estimate the applicability of BBPD in more diverse markets featuring homogenous, non-durable goods. The next chapter starts by discussing asymmetric demand, whilst keeping information symmetric between the firms.

3 Asymmetric demand

The previous chapter discussed merely whether a customer has preference to A or B. The models of asymmetric demand, however, allow loyalty to vary across the customers or, alternatively, assume firms to differ in some characteristics. In other words, either some people are choosier than the others, or more customers prefer A than B. Demand asymmetry is a realistic assumption since firms typically differ in terms of their customer base. For example, it has been estimated that Amazon's customers are more loyal than those of Barnes and Nobles (Goolsbee and Chevalier in Acquisti and Varian 2005). Thus, the demand for Amazon differs from the demand for Barnes and Noble. When customer bases are heterogeneous, firms' demands are asymmetric. Furthermore, Armstrong (2006) hints that firms could benefit from discrimination based on loyalty. Therefore this chapter examines whether firms facing differing demands could indeed beneficially practice behavior-based price discrimination.

3.1 Asymmetric loyalty

Shaffer and Zhang (2000) consider asymmetric demand that derive from differing customer loyalties. They aim to explain why poaching is not a universal phenomenon if results would be as robust as the early literature implies. Shaffer and Zhang point out that some firms find it optimal to give discounts to own customers instead of the rival's customers. To understand when it is optimal to "pay to stay" or to "pay to switch", they first assume that the market is already shared with some unequal division between the firms. There is no information collection period and the model is purely static. Shaffer and Zhang are interested in the relative loyalty of the customers. They define customers belonging to A's market to have an average loyalty of l_A and correspondingly l_B for B. The differences in loyalty affect the pricing decisions because they represent differentiated cost of switching for the customer segments. In the terminology of Thisse and Vives, the segments have different transportation parameters (here loyalty) and customers are not uniformly distributed.

Shaffer and Zhang find that firms may in fact avoid intensified competition under certain loyalty profiles. The general outcome is that the firms should always set a low price to the customer segment with the highest cross-elasticity for the firm's product. In other words, if the rival's customers have higher price elasticity than own customers, the firm should pay to switch. On the other hand, if own customers were more elastic towards the firm's product than the rival's customers, the incumbent should to pay to stay. Hence, both firms will poach when the relative difference between the loyalties is low, as is the case with symmetric demand. When own customers are the more elastic group for one firm but not for the other, the first pays to stay while the other tries to poach the rival. Figures 3(a) and 3(b) illustrate the situations.

Figure 3(a)   **Figure 3(b)**

Height of the box represents the average loyalty of each firm's customer base. When A has highly loyal customers and larger market share, as in 3(a), B is forced to poach aggressively in order to generate poaching profits. This in turn intensifies the price competition in A's market and A must respond to the poaching by setting lower price to own customers. Firm A also finds it profitable to poach B's market due to B's customers' the relatively low loyalty. Both firms follow in this case the pay to stay strategy. The figure 3(a) pictures the same asymmetric best response scenario as the earlier models with symmetric demands.

In the case of 3(b), on the other hand, B is the firm with highly loyal customers. As B knows that all A's customers prefer A to B but are not loyal, it is beneficial for B to poach A's market. Note that knowing that its customers are easy to poach, A must respond aggressively to protect its market share. In this case, A sees it optimal to pay its customers to stay which drives the price in A's market

down. B, on the other hand, is strictly better off due to behavior-based price discrimination, because it can increase price in its own highly loyal market while gaining also some poaching profits from A's market. Conversely, A must lower price both in its own market as well as in its poaching market. Here A pays to stay while B pays to switch. Shaffer and Zhang further show that there can be such a loyalty relation that both firms are better off under BBPD. When B's customers are significantly more loyal than A's, B will find it optimal to concentrate in exploiting its own customers' strong preference and neither has to lower the price for the own customers.

Also Shin and Sudhir (2010) discuss the strategic choice of paying to switch or paying to stay. Contrary to Shaffer and Zhang, here firms choose different strategies depending on the assumed preference stochasticity. Shin and Sudhir show that relaxing the assumption of fixed preferences may be sufficient to generate profitable behavior-based price discrimination. Previous models have assumed constant preferences, because allowing preferences to be random would make the customer data worthless. The fixed preferences are also one reason for the aggressive poaching in the earlier models. When customers have constant preferences, firms know that only low introductory price can induce them to switch. Shin and Sudhir go about this by adding a stochastic shock term to consumers' preferences. When the shock term is small, only the inframarginal consumers' preferences change. As stochasticity grows (i.e. shock term increases) preferences change for a larger fraction of customers. Stochastic preferences seem a very realistic assumption since people seldom remain loyal to one firm forever. For example, industries with innovation are likely to encounter changing preferences. Nokia might not wish to offer low introductory offers for Samsung users since a new model might induce some Samsung customers to switch in any case.

When preference stochasticity is low, i.e. preferences are constant, Shin and Sudhir conclude that firms pay to switch. On the other hand, when preferences are allowed to change between periods, the firms may choose the pay to stay strategy. The intuition is that when customers are more likely to start to prefer the rival, it is optimal for the incumbent to "poach" its own customers. This leads

to a mismatch in the second period as some customers stay with the less pre-ferred incumbent because it offers a low enough price. The model of Shin and Sudhir and that of Shaffer and Zhang depict the same dynamics. High stochastici-ty can be interpreted as the probability of having less loyal customers. When there is a high likelihood that on average the customers are not loyal, the firm chooses to provide discounts to its own customers. On the other hand, with low probability of indifferent customers it becomes profitable to poach rival.

The interesting outcome in Shin and Sudhir's article is that the firm's incentive to offer really low poaching prices reduces as stochasticity increases. Since part of the second period customers will switch to the other firm even without a price cut both firms reduce poaching. However, the effect of decreased price sensitivi-ty in brand preference models, which enables the firms to price higher in the first period, decreases when stochasticity grows. In other words, once customers consider that they are likely to switch in the next period, higher price sensitivity in the first period forces firms to lower prices. For certain values of preference stochasticity, profits can however increase under BBPD even with symmetric information.

Overall, the conclusion for consumer welfare is that when the smaller customer group is the most loyal one, it is also the one who loses most compared to uni-form pricing. The larger group is better off if they are the least loyal but they can also be made worse off if the loyalty discrepancy is large enough. Apple and Mi-crosoft operating systems show an illustrative example of this. Apple's consum-ers represent the case in figure 3(b), as Apple is typically considered to have high brand loyalty but small market share. Since Apple's products are costlier than the rival's products, it would seem that the Apple consumers end up paying for their loyalty. Microsoft, on the other hand, practices pay to stay strategy e.g. by offering lower upgrade prices to the existing customers (Shaffer and Zhang 2000). In this case, Microsoft must rely on recognizing old customers. At least for now, it seems that Apple does not bother poaching Microsoft's customers. If Ap-ple's average loyalty dilutes as its market share grows, the theory would predict

that Apple might also be induced to separate customers based on purchase history and apply poaching strategies.

3.2 Asymmetric firms

Although the results of Shaffer and Zhang (2000) shed light on the firms' strategic options under BBPD, the static nature of the model leaves an open question. Since the competition for the market share is not taken into account, the model might foster similar features as those with switching costs. In the dynamic models, the firms take the second period outcome into account in their first period decision-making. Customarily, in the BBPD models with switching costs, firms realize that the first period market share affects the outcome in the second period. Alternatively, the firms might differ in some characteristics which causes a larger fraction of the customers to prefer one firm to the other. This asymmetry in the firms characteristics can also have significant impact on the outcomes.

Therefore, this section discusses dynamic models with asymmetric firms. Pazgal and Soberman (2008) assume in one specification of their model that the other firm has greater ability to add benefit to consumers in the second period. Since this benefit would be lost if the customer switches in the second period, it means that one firm is able to generate higher switching costs than the other. Hence, the firms are no longer assumed identical. Pazgal and Soberman find that sufficiently high discrepancy between the switching costs would induce the weaker firm (in terms of lock-in ability) to abandon price discrimination altogether. In this situation, it becomes natural that the firm practicing price discrimination profits from it. Behavior-based price discrimination is always beneficial when only one of the firms is able to implement it.

Similarly, Chen (2008) concludes that substantial discrepancy between firms' marginal costs may enable profitable discrimination. The mechanism for profitability is the same as in Pazgal and Soberman with only one of the firms being able to price discriminate. Contrary to Pazgal and Soberman, the key driver here is the ability to conduct efficient predatory pricing. By addressing competitors' cus-

tomers with prices lower than the rival's marginal cost, the stronger firm can force the weaker one to exit.

Chen's and Pazgal and Soberman's models differ substantially from the other papers of BBPD since firms are not assumed to be identical. This also enables studying the anticompetitive effects of BBPD. These effects are important to understand since they can have a profound impact on markets. The discussion about the anticompetitive effects of behavior-based discrimination is, nevertheless, outside the scope of this thesis.

An interesting feature in Chen's paper is that discrimination is profitable because the discriminating firm becomes a monopoly. Chen does not, however, contemplate what happens after the stronger firm becomes a monopoly. Villas-Boas (2004) as well as Acquisti and Varian (2005) both conclude that monopoly is strictly worse off by being able to recognize customers compared to applying uniform pricing. They discover that customers' strategic behavior creates similar problem as in durable-goods monopoly. That is, the monopoly can increase profits only by lowering the price to attract a wider market. This in turn gives all the customers an incentive to wait for the lower next period prices. Furthermore, the customers are imposed to a ratchet effect; revealing one's preferences in the first period makes them worse off in the future period as the information is used to discriminate them. The monopoly suffers because a part of the potential first period customers postpone their purchase in order to get the lower price in the second period.

Acquisti and Varian (2005) conclude that price discrimination can be profitable for monopoly when customers have differing preferences. While in duopoly models the preferences vary between the firms, in monopoly they must differ with respect to some add-on services the monopoly offers to recurring customers. In other words, monopoly benefits only if some customers appreciate the add-on service more than the others and the service's value depends on the information shared in the first period. Due to the increasing marginal benefit the monopoly is able to effectively attract customers into revealing their true identi-

ties. The recommendation feature of many online stores is one example about an add-on service. The customer can receive recommendations only after having bought something and the more information one shares with the retailer the better the recommendations become.

Overall, it would be interesting to find more research about the effects of asymmetric demands. Demand asymmetry is a very realistic starting point and full understanding of how it affects behavior-based discrimination would be useful. Both of the dynamic cases point to profitability stemming from the unilateral discrimination, while the static case of Shaffer and Zhang claims that both firms could benefit from BBPD. It would hence be beneficial to know whether or not the latter result derives from excluding the "first period" effects (i.e. the period of information gathering).

4   Asymmetric information

As pointed out in the second chapter, though being optimal choice for all firms, behavior-based price discrimination is often harmful under full symmetry. Since it was shown in the chapter three that discrimination can be profitable with sufficiently asymmetric demand, it becomes interesting to next ask if altering also the other part of the symmetry has similar effects. Therefore, this chapter therefore discusses what happens when there is informational asymmetry, that is, the firms are able to obtain private information. Information asymmetry can arise due to two reasons; either the other firm is unable to gather information due to incomplete addressability (as in Esteves 2009) or the firms can gain additional information that is not visible to the rival about their own customers. In the afore-mentioned case, asymmetry is endogenously created in the model, while for the latter case asymmetry results from customer characteristics.

Asymmetric information has not been examined as explicitly as symmetric information in the behavior-based price discrimination setting. Majority of the papers that find BBPD profitable do so due to asymmetric demand or sufficient lock-in. Thus, being able to segment the own customers to highly valuable and

less valuable groups benefits the discriminating firms. However, as Shy and Stenbacka (2011) point out, information asymmetry is essential if there are no captive customers. If firms had symmetric information about relative loyalties, the rival could just better target its poaching offers. After all, there would be more markets to compete head on and as the market segments increased the situation would resemble perfect discrimination. Thus, it may be that information asymmetry can make discrimination profitable even in the situations where it was earlier found clearly harmful.

4.1 Endogenous asymmetry

Since behavior-based pricing is profitable when only one of the firms is able to practice it, the firms have a unilateral incentive to create asymmetry with respect to horizontal information. This is in essence obtained when either of the firms serves the entire market in the first period, or alternatively, if one firm is not able to separate poaching market from its own customers due to limited addressability. In this section I will discuss the latter scenario.

Esteves (2009) extents behavior-based price discrimination to the discussion of limited addressability. She views marketing as a way to inform customers about prices. Without advertisement from both firms customers cannot compare the prices and hence part of the consumers become captive. The rest of the customers get ads from both firms and become potential switchers. The model features neither switching costs nor brand preferences, so only the price affects the choice. This makes the reach of marketing decisive for firms. The firm whose price is the lowest gains all the customers that receive advertisement from that firm. The high price firm only gets those customers who do not receive the low price ads from the rival. Thus, the high price firm is able to separate own customers and poaching market, while the low price firm only sees own customers. This creates information asymmetry.

In addition to the pricing decision, the firms have to choose the reach of their marketing activities. Note that if both firms send ads to all customers, the situation reverts to a prisoner's dilemma. Therefore, both firms maximize marketing

coverage subject to not intensifying the competition for the shared customers too much. Both firms simultaneously try to achieve two conflicting aims: a large poaching market and a large extraction market. Just as in Villas-Boas (1999), when a firm has a large market share, it becomes less aggressive in its poaching market. This means that neither firm wants to cover the entire market since that would intensify price competition just as it does with larger poaching market in Villas-Boas (1999).

Both firms benefit because behavior-based pricing increases prices in the first period, but also reduces competition in the second period. The latter enables the high price firm to reap poaching profits, while allowing also the low price firm to increase its uniform price to its large captive market. The larger the marketing coverage is for both firms, the more there is competition and switching in the second period. Esteves (2009) notes that depending on the cost of marketing, firms may advertise too much or too little compared to what is socially optimal.

Though featuring endogenous information asymmetry, Esteves' model is very similar to that of Chen and Zhang (2009) with symmetric information. In both papers the mechanism for profitable discrimination is screening. In addition, part of the market is assumed to be captive which reduces poaching significantly. This would imply that the profitability of BBPD in Esteves (2009) does not necessarily derive from information asymmetry as it does from captivity and screening. The next section moves on to models where all customers are potential switchers but information asymmetry is exogenous.

4.2 Exogenous asymmetry

It was shown that perfect information about brand preference and loyalty leads to prisoner's dilemma. However, consider firms learning brand preference collectively but loyalty unilaterally. This chapter discusses the situation where firms are able to gain private information about loyalty while information about brand preferences is symmetric between the firms.

Shin and Sudhir (2010) study the effects of asymmetric horizontal information. Their model includes also discussion about preference stochasticity, but here preferences are assumed fixed. Shin and Sudhir's model does, however, differ from the conventional BBPD models in one other aspect. They consider customers to differ not only in terms of horizontal preferences, but also vertically with respect to quantity demand. There are four customer segments; high demand group preferring A and B respectively and low demand segments similarly for A and B. Horizontal preference is assumed uniformly distributed, i.e., demands are symmetric. Thus, the possible benefit from BBPD cannot derive from large discrepancies between the demands the firms face as in the previous chapter.

Information about quantity is significantly different from the information about loyalty. High demand customers do not have higher "resistance" towards the other firms poaching than low demand customers. As already noted, duopolies cannot discriminate based on vertical information. To enable discrimination, firms have to generate switching costs to the high demand customers by offering them discounts. This way the high demand customers become loyal, while low demand types remain unaffected. This is also what firms typically do: offering loyalty discounts keeps the rivals away from the incumbent's most profitable customers. The pay to stay strategy can hence also derive from the need to create horizontal differentiation between the firms. In this case, loyalty discounts are the cost of obtaining the ability to discriminate.

Differences in the demand quantities and the following loyalty discounts constitute a substantial problem for the poaching firm. When the low demand customers are the ones most likely to be poached, the rival faces a classic lemons problem. This is clear in a specification such as Shin and Sudhir's where the least valuable customers in terms of demand quantity are the ones most prone to switch. The lemons problem is highly significant for the other BBPD models as well. Fudenberg and Tirole (2000) point out that poaching may not be that lucrative in multiple period models because the ones who switch are the most likely to switch again in the next period. Hence the best customers, i.e., the loyal ones,

remain mainly unaffected by poaching and only the least valuable customers swap.

The lemons feature is also the one that determines the outcome in Shin and Sudhir's model. When difference between the high and low demand types is sufficiently large, the rival realizes that it will disproportionally poach low demand customers. Thus, the rival becomes less aggressive in its poaching enabling both firms to set higher price for the low demand segments. Reducing competition in one segment while increasing extraction profits in the other makes both firms better off under BBPD.

Figure 4

Figure 4 illustrates the situation in Shin and Sudhir (2010). The height of the box represents here customers' switching cost. Note that A has no visibility to B's customers apart from knowing their brand preference (i.e. half buy from the rival in the case of uniform distribution). Conversely, A knows more about its own customers than in the models of pure brand preference information. Because B cannot segment A's market to subgroups, it can only set one price there. Firm A, on the other hand, can set two prices depending on the customers' demand quantities in the first period. This enables A to gain more extraction profits: instead of getting just areas 2 and 3, it also gets area 1 from the high demand group. Contrary to Thisse and Vives, rival cannot set corresponding poaching prices, which reduces the size of the poaching market. As B will most likely just get the low demand types, it will not suppress the price that much. Firm A will react similarly in B's market. Hence, both firms are able to set higher price for the low demand types without facing competition for their high demand types.

Naturally the firms have to set lower price to the high demand types to create the sufficient switching costs. Shin and Sudhir therefore restrict the high-types' demand to be sufficiently large to ensure that they are always more valuable than the low-types. Further, as already noted, the difference in the demanded quantities must be adequately high to make the switching costs worth creating for. Additional requirement for profitable discrimination is that there is a large enough fraction of high demand customers. This feature is not discussed in Shin and Sudhir as uniform distribution is the primary assumption. However, considering the results in Shaffer and Zhang (2000), the size of the loyal market is likely to matter.

Interestingly, another study with information asymmetry by Shy and Stenbacka (2011) runs into completely different outcome. They examine a situation where firms learn their customers' loyalties in addition to recognizing whether a customer purchased from the rival or not. Here loyalty is exogenous and does not have to be compensated for in the price. The model of Shy and Stenbacka is also static contrary to Shin and Sudhir (2010).

In this setting, Shy and Stenbacka show that asymmetric information about loyalties is clearly better for the firms than symmetric information. This is due to the same reason why Thisse and Vives find perfect discrimination harmful. Under asymmetric best-responses, as in Shy and Stenbacka (2011), symmetric information brings no additional benefit because both want to approach different customers with low prices. In addition, the more precise information actually makes them worse off because the rival also learns the optimal poaching prices. There are more markets in which to compete head-on, whereas under asymmetric segment recognition firms are able to increase extraction profits without the fear of competition. Thus, it is never optimal for a firm to share information under best response asymmetry.

Further, more consumers switch compared to asymmetric information scenario, making information exchange also socially undesirable. Conversely to Shin and Sudhir's results, Shy and Stenbacka find that uniform pricing is still the optimal

strategy and behavior-based pricing makes the firms worse off. Shy and Stenbacka note the opposing results, but do not offer insight on where the difference might stem from.

The model of Shy and Stenbacka differs in one respect substantially from the other papers. While most dynamic models assume the first period prices to be uniform and therefore the allocation of customers to be efficient, Shy and Stenbacka assume the initial allocation to be inefficient. That is, they start with part of the customers being mismatched. Implicitly this result can be obtained if preferences are not constant, firms apply random pricing (as in Esteves 2010) or addressability is not complete (as in Esteves 2009). The initial assumption of mismatch generates additional costs to the model that the other models do not consider. It would be interesting to examine the model without the mismatch cost and see how that affects the outcome. The mismatch loss affects probability of switching in the model, so this term definitely has an impact on the poaching prices and therefore on the profitability of BBPD. Further, the results could be compared with better accuracy to those of Shin and Sudhir (2010).

Overall, the effects of information asymmetry should be granted more research. The models currently at hand offer encouraging but divergent results and require reinforcement. It seems that endogeneity of asymmetry is not such an important aspect, as similar outcomes can be obtained even with symmetric information. However, the inclusion of endogenous switching costs would be valuable. Shin and Sudhir (2010) achieve this endogeneity and thus form a model that takes into account how loyalty is created.

5   Constraints on discrimination

This far the discussion has been focusing on the firms' incentives to discriminate, but there are also other aspects that affect the firms' ability to implement discrimination. The most severe constraint for discrimination in general is the existence of second-hand markets. A major problem for a firm discriminating on prices is that if there is a second hand market for the good, there will also be ar-

bitrage. Customers who are able obtain the good at a low price benefit by selling it to the high valuation customers in the second-hand market.

However, behavior-based price discrimination may also offer some protection against second-hand markets. Significantly, collecting data on customer's purchase can be used to ensure that the same customer also uses the product (Odlyzko 2003). For instance airlines' yield management pricing is dependent on the ability to force the customer to identify herself at the time of the purchase, thus effectively destroying any second-hand markets. In other instances customer recognition may not be as complete but even some degree of identification may restrict the formation of second-hand markets. Simply put, firms who want to discriminate based on customer behavior will need the data not only to estimate the customer's willingness to pay, but also to deter second-hand markets.

There are, however, few constraints that are characteristic to behavior-based price discrimination. Firstly, the customers' ability to hide or anonymize themselves makes discrimination less profitable for the firms due to arbitrage in the same manner as second-hand markets. Anonymization is especially prevalent in online environments. While firms are able to effortlessly recognize customers through cookies and IP-addresses, customers can equally effortlessly delete those cookies or use different IP-addresses to appear to be someone they are not. Secondly, customers' moral objection to this type of discrimination may be strong enough to deter firms from ever implementing it. The best example is Amazon's experiment on customer-based pricing of DVDs. The customers' outrage forced Amazon to refund customers and withdraw from the experiment. This chapter takes a closer look into these two BBPD-specific constraints: fairness and anonymization.

5.1 Fairness

Assuming that customers are not myopic, but instead realize that they face different prices depending on their choices today, it is good to discuss briefly the implications of psychology. As came evident in Amazon's test-run on dynamic pricing, customers can find price discrimination offensive and rebel against any-

one implementing it. Thus, I will point out few key issues about discrimination and fairness and how this may affect firms' behavior.

First of all, fairness is clearly a highly subjective term. Kahneman et al (1986) argue that people evaluate fairness in trade by benchmarking the features (such as terms of sale, time and seller of a specific transaction) against some reference transaction (such as a past purchase or transaction by some other customer). That is to say, people compare transactions against some benchmark from their own or friends' experiences to estimate if the transaction at hand is according to norms.

In some instances finding a valid reference transaction is not that straightforward. For example in the service sector it is often difficult to show that conditions of trade were the same. Thus differing prices are easier to explain and accept. In general, when customers feel stripped of the possibility to affect prices they respond negatively to the transaction (Acquisti 2004). That is why people accept easily quantity or student discounts, but object price discrimination when they do not know why the price is different for them.

According to the experiments of Haws and Bearden (2006) people find pricing unfair most often when the price differs from that for other consumers or when pricing changes within a short time period under similar conditions of trade. The survey of Kahneman et al (1986) confirms this inclination. Their survey asked about the fairness of a landlord raising the rent after hearing that the tenant got a job nearby the house and would thus be less willing to move out. Nine out of ten respondents found it unacceptable for landlord to use private information to reap higher rent. As this is precisely the context of BBPD, the studies would imply that this type of pricing is inclined to face strong objection.

Furthermore, it has been demonstrated in many experiments that people are actually willing to encounter costs just to punish unfair behavior. Take for example the ultimatum game, an experiment where a player proposes how to divide the sum between two players while the second player either accepts or rejects

the offer. It has been repeatedly shown that people often decline positive offers if they find the allocation to be unfair. Kahneman et al (1986) introduce also another study where students were given an alternative to share $10 evenly with a person who had in the previous round been fair in the Ultimatum game or share $12 evenly with a person who had been unfair. In this experiment as well people rather punished "bad behavior" than gained an extra dollar. This type of behavior is probably what Amazon feared and tried to remedy by refunding the angry customers.

As price discrimination has the tendency to lead to Bertrand competition in homogenous good markets, the firms may even welcome the public outrage as means to avoid the harmful discrimination altogether. Odlyzko (2003) cites a U.S. railway case as a situation where both customers and firms were happy to ban price discrimination – although it reduced total welfare. In the beginning of the last century U.S. railway price discrimination was banned by law due to wide public objection of the pricing practices. Similarly, the firms that end up in prisoner's dilemma due to the ability to recognize customers might wish for the government to prohibit discrimination. Unilateral withdrawal would make individual firm worse off, but universal ban due to public opinion would benefit the firms jointly.

These results overall deem bad prognosis for behavior-based pricing. Not only do people find behavior-based pricing unfair, they are also willing to punish unfair behavior even at a cost to themselves. However, what is considered unfair today need not be unfair tomorrow. When a certain practice becomes common, people start to view it as fair even though it was previously considered unjust (Kahneman et al 1986). This is because the benchmark transaction changes over time.

A good example about this numbness effect is the yield management technique airlines use for pricing (Xia et al 2004). This type of dynamic pricing has become widely accepted and utilized in various transportation industries and was lately adopted in the Finnish railways as well. Especially noteworthy is that in the 1986

study by Kahneman et al, the respondents found it unfair to take advantage of peak demand. This is basically what yield management technique is all about. Although exploiting peak demand was considered unacceptable 25 years ago, today it is viewed to be business as usual in certain industries.

5.2 Anonymization

Another significant limitation for behavior-based price discrimination is anonymization. Anonymization refers to customers' ability and incentives to hide their true identity. Anonymization is hence closely linked to privacy. When people are not able to hide their identity, they may be forced to give away private information. Privacy as an economic phenomenon includes many aspects, ranging from the moral hazard of firms that under protect their databases against hacking and data thefts to the optimal contract structure for the private information. This section focuses only on the aspects of anonymization and privacy that are closely related to behavior-based price discrimination. For introductions to the other themes, see e.g. Varian (1996), Odlyzko (2003) and Acquisti (2004).

Anonymization is especially topical in electronic environments where firms are increasingly able to recognize customers with or without the customers' explicit approval. For example, many online stores track customers' clickstream, i.e. the items they view. Further, it is possible to see from which website the customer entered the online store, were it from Google search results or influential blogger's website. Firms are also able to recognize recurring customers based on cookies they add on the web-browser the customer uses. All this reveals potentially valuable information about the consumer. A customer who visits the store from a blog might be less price sensitive than customer who googled the product. Or customer's clickstream might indicate what the customer is interested in while frequent visitor exposes her loyalty.

Recognition is not, however, confined to the online world. "Offline" recognition with loyalty card, ID-card or coupons is an equally common practice. The major difference is the ease of anonymization. Leaving a loyalty card in the wallet requires less sophistication than removing cookies from web-browsers. As much of

the data collection in online stores is invisible to customers, anonymization is undoubtedly more difficult online than offline. However, online and offline are likely to blur if the multichannel retail envisioned in HBR's article materializes. If customer's mobile phone gives away the identity already at the entrance, it no longer matters whether the loyalty card stays in the wallet or not. This clearly creates new challenges for anonymization.

Another interesting question is whether the customers have better ability to act strategically with respect to brand preferences or to loyalty? One could reasonably argue that hiding brand preferences is easier. Pretending to be new customer is relatively simple in most of the markets. For example, the customer can remove cookies from the webpage or apply for a new loyalty card. Loyalty again means that the customer has higher cost of switching than some other customers. Because the switching cost is not assumed to be something the customers can choose, they have less chance of hiding their loyalty. When firms are able to find out who the high switching cost customers are, they can use this information to their advantage.

Acquisti and Varian (2005) show that monopoly has always an incentive to make anonymization as difficult as possible to its customers. When the consumer cannot pretend to be new, the monopoly is able to set a lower price for those customers who did not buy in the previous period without having to cut the price effectively for everyone. Many of the papers on duopolies unfortunately do not discuss customers' strategic behavior in much detail. Esteves (2009), however, notes that some of the captive customers for the high price firm may wish to forgo purchase in the first period to appear as though they bought from the rival. Similarly some customers could choose to buy from the less preferred firm in the first period just to be identified as low valuation customer by their most preferred firm.

The choice of whether to offer anonymization or not is not that straightforward though. Acquisti (2004) argues that a major problem with firms' reluctance to offer anonymizing technologies is that customers who are wary about their iden-

tity refrain from buying if they are not offered the tools to hide. It has been calculated that at the peak of the privacy scare in the late 1990s, the fear of identity thefts and credit card frauds caused billions of dollars' worth lost sales (Acquisti 2004). Privacy concerns are likely to increase again now that hidden tracking software, and such, have been found on eminent platforms like Apple and Google. Although on one hand the firms may have an incentive to restrict anonymization, there is clearly both internal and external pressure to offer tools for anonymization. The fear of lost sales may be one reason why Amazon for instance allows customers decide whether they want to provide the data about their purchases and clickstream.

Taylor (2004) argues that strategic customers have an incentive to create disinformation when they expect firms to exchange customer data. For example, by postponing purchases customers can pretend to have low valuation for the good. This harms not only the firm collecting data via lost sales, but also destroys the validity of the data collected.

An interesting addition to the problematic of anonymization comes from the situations where it is socially optimal to allow the firms to exchange information. Under best-response symmetry firms benefit from information exchange (Armstrong 2005). When customers have no possibility to anonymize, the loss generated from the customers' strategic behavior disappears and the firms may profitably share information. An applicable example would be the banking sector. All banks wish to apply higher prices (e.g. interest rate) to the high-risk customers and vice versa for the low-risk customers. In other words, there is clear best-response symmetry. Furthermore, all customers must by law identify themselves when visiting banks, eliminating straightforward anonymization. In this setting it becomes profitable for all banks to share information about the customer's trustworthiness (Pagano and Jappelli 1993). Hence, only in the case of symmetric best responses and myopic customers would firms be able to benefit from sharing customer data. In situations where better coordination removes serious adverse selection problems, anonymization may prove socially harmful.

In sum, anonymization has both negative and positive impact on firms. On one hand it makes discrimination more difficult, but on the other hand not offering the opportunity to hide may cause lost sales. Anonymization has also ambiguous welfare effects depending on whether information exchange between firms is socially desirable or not. Although the demand for anonymization technologies is currently feeble, I would argue that recent information thefts (e.g. from the gaming service Steam) and exposures by Wikileaks are likely to increase interest towards them.

6 Conclusions

Price discrimination based on customer identification is perhaps easier than ever. Not only is it currently technically possible to automatize pricing based on various attributes but also customers are more and more willing to share their identities with companies via mobile applications, loyalty cards or online identification. As firms already collect behavioral information about customers, it is crucial that economists can evaluate the effects this information has on market dynamics. Furthermore, as customers become increasingly aware of the data collection and its implications, this awareness may alter their behavior with substantial impact on the firms' incentives. With the recent scandals concerning collected customer data, people are likely to become more wary with their private information.

The research thus far indicates that behavior-based price discrimination is a double-edged sword; on one hand it enables extraction of consumer surplus, but on the other hand the incentive to gain poaching profits brings along intensified competition. The profitability of behavior-based pricing depends thus on the balance of these profits. If firms can gain enough extraction profits to offset the negative effect of increased competition for poaching profits, they can benefit from behavior-based price discrimination.

This far the literature has not been able to show that both firms could discriminate profitably when firms share symmetric information about symmetric brand

preferences or switching costs – except for the special cases of captive customers and stochastic brand preferences. However, relaxing either of the rather strong symmetry assumptions has been shown to make profitable discrimination possible. As symmetry restrictions are relaxed, the incentives for focusing on extraction and poaching profits change. Under symmetry, both firms benefit by unilaterally pursuing poaching profits. Once demand becomes asymmetric, firms may wish to focus primarily on the extraction profits. More subtle information also enables separating the loyal customers from the indifferent ones, thus offering the firms access to asymmetric information. It seems that when firms can obtain asymmetric information, they can escape the prisoner's dilemma that symmetric information and demand bring along. Hence, improved customer recognition seems to be valuable both in increasing extraction profits as well as in reducing rival's poaching profits.

Behavior-based price discrimination is, however, severely affected by few constraints. The notion of fairness plays bigger role in behavior-based pricing than it does in many other types of discrimination. People generally appear to object pricing if their price is different from that of the other customers' without an obvious reason or if the seller exploits consumer's personal information to her own advantage. There are, nevertheless, differences in how strongly people react to behavior-based pricing. Most consumers do not object introductory offers to new customers, so the very basic discrimination based on brand preference seems widely accepted. In contrast, the attempts of online stores to apply more sophisticated pricing schemes have failed notoriously.

Another significant obstacle for efficient behavior-based discrimination is anonymization. If customers are able to hide their true identities, they can repeatedly benefit from introductory offers or prevent the exploitation of their purchase histories. Anonymization is a major threat for firms that would like to discriminate based on the collected customer information. Although firms would prefer not to allow customers to hide their identities, they should offer some anonymization. Firms face a trade-off between efficient discrimination and the lost sales to privacy-sensitive customers. At the moment the technologies for anony-

mization are not very sophisticated but the exposures of unauthorized tracking and the general awareness of how the information can be used are likely to increase the demand for such technologies.

Behavior-based pricing has not only ambiguous effect on the firms' profits but also on welfare. The more intense the competition for switchers becomes, the larger is the consumer surplus. The customers with smallest switching costs are the ones who benefit most. But with more switching also the welfare loss associated with inefficient switching grows. However, if lower prices in poaching market are able to increase demand, behavior-based pricing can be beneficial for the economy. In addition, switching does not need to be inefficient if preferences are allowed to change in time.

Although it might be socially desirable to restrict behavior-based pricing at least in some instances, I would argue that a ban on discrimination is not feasible. Firms cannot be prohibited from changing prices and especially in the online markets prices can change within seconds even without discrimination. It would be impossible to show that price change had been caused by discrimination and not e.g. due to stock-level changes. Even if product prices were held constant, nothing would prevent firms from discriminating instead on delivery fees. Therefore the question is not that much whether firms must price uniformly by law but whether they find it profitable to discriminate.

6.1 Future research

In my opinion, an important issue that the literature should decide upon is the exact definition of behavior-based price discrimination. Thus far the literature has concentrated mostly on discrimination between own and rival's customers. Only the most recent papers consider additional information about customers to affect the firms' decisions. In reality, firms have a strong incentive to learn to know specifically their own customers in terms of loyalty or product preferences. In online markets and much of the other retail of non-durable goods, firms' main interest is to learn to know the customer. For instance, Amazon collects purchase data in order to recommend new products, while grocery stores

aim to recognize their most valuable customers. Obviously, in both cases the firms try to understand their customers to extract more profits out of them.

If we consider behavior-based price discrimination to include on any information about purchase histories, the traditional theory of third degree price discrimination should be brought forward more explicitly. Once firms can discriminate among own customers without the rival recognizing the different customer segments, situation reminisces much that of a monopoly. Similarly to monopoly, there would be private information about the customer segments that only one firm can exploit. It would also be interesting to see how firm's poaching decision is affected when the firm knows its own customers, but knows nothing about the distribution and qualities of the rival's customers.

In my view, the most promising venue for future research lies in the area of information asymmetries. It has been quite extensively shown that symmetric information has the ability to intensify competition, making the firms worse off compared to uniform pricing. Asymmetric information about qualities that differentiate own customers seems valuable instead. Features that differentiate customers are also potential sources of differentiation between the firms. By enhancing loyalty, the firms effectively create higher switching costs for the customers. This in turn enables efficient discrimination and profit extraction. A customer who has just reached the platinum level for her loyalty card is significantly less likely to switch to the rival even if the incumbent's prices are slightly higher.

The studies reviewed in this thesis confirm the value of loyalty. However, what most of the models neglect is that loyalty must be created and sustained. As in Shin and Sudhir's model, firms need to compensate the most valuable customers to keep them loyal. The firms also need to recognize the consumers in order to compensate the right customers in the right way. Hence there is a clear tradeoff between boosting loyalty and extracting profits that the simple models do not take into account.

In my opinion, to fully grasp why firms collect data on customers and how they can use it, the literature needs to treat loyalty as an endogenous variable, not as an inherent characteristic of a certain type of customer. That is, customer data matters because it reveals also something about the customers' vertical preferences, not just about horizontal preferences. The firms can use information about the vertical preferences in deciding how strong a horizontal preference they want to create for each customer. For example, Acquisti and Varian (2005) show that differing vertical preference for an add-on service, such as recommendations, is pivotal for successful discrimination. Similarly, grocery stores reward the customers with the most expensive purchases to keep their cash flow out of the rival's reach, while ignoring the customers who buy equally from both firms. Although neither monopoly nor duopoly is able to discriminate directly based on vertical customer information, the data enables the firms to segment customers. By creating differing switching costs for the different groups the firms may profitably discriminate among them.

Overall, the effects of collecting customer data are increasingly important in economics as well. Economists should be able to evaluate the implications of customer data acquisition with reasonable confidence. We need to be able to assess why some firms might want to discriminate based on customer behavior while others do not. By recognizing the winners and the losers, we may argue who are the ones in the need of protection. The market is predicted to become more electronic both in terms of pricing and customer recognition. The visions of customized offers "at the right time, at the right price, and in the right channel" trumpet for better ability to recognize and price discriminate customers. The progress is likely to accelerate once brick-and-mortar stores start to compete more intensively against online stores with constraints like fairness and anonymization affecting the situation. Current research in the field provides some tools to grasp the problematic, but there is still much to work left to reach consensus. I fully agree with the authors of behavior-based price discrimination literature that this is a fruitful area of economics for future research.

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