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**"A Survey on the Economics of Behaviour-Based Price Discrimination"**

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# A Survey on the Economics of Behaviour-Based Price Discrimination

Rosa Branca Esteves

## 1 Introduction

> "*Information technology allows for fine-grained observation and analysis of consumer behaviour. This allows for various kinds of marketing strategies that were previously extremely difficult to carry out, at least on a large scale. For example, a seller can offer prices and goods that are differentiated by individual behaviour and/or characteristics.*"
>
> Hal Varian (2003), *Economics of Information Technology.*

Economists have long been interested in understanding the profit, consumer surplus and welfare effects of an ancient marketing strategy: *Price Discrimination.*

While it is not new that firms try frequently to segment customers in order to price discriminate, what has dramatically changed, with recent advances in information technologies, is the quality of consumer-specific data now available in many markets and how this information has been used by firms for price discrimination purposes. Specifically, thanks to information technology it is nowadays increasingly feasible for sellers to segment customers on the basis of their purchasing histories and to price discriminate accordingly. This form of price discrimination has been named in the literature as *Behaviour-Based Price Discrimination* (BBPD).[1]

For a long time economists have been concerned in understanding the economic effects of price discrimination in monopolistic markets.[2] However, because imperfect competition is undoubtedly the most common economic setting, recent research on the field has been concerned with the following issues. Firstly, how are profit, consumer surplus and welfare affected when firms practice some form of price discrimination in imperfectly competitive markets? Secondly, in which circumstances may competitive firms have an incentive to price discriminate or rather to avoid it?

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[1] For a comprehensive survey on behaviour-based price discrimination, see also Fudenberg and Villas-Boas (2007).

[2] For a survey of price discrimination with monopoly see, for instance, Varian (1989).

As we will see, conclusions regarding the profit and welfare effects of price discrimination are strongly dependent upon the form of price discrimination, which in turn depends upon the form of consumer heterogeneity and the different instruments available for price discrimination. Basically, the aim of this survey is to clarify the two aforementioned issues in imperfectly competitive markets.

## 2 Some Useful Concepts

Broadly speaking, price discrimination exists when the difference in prices among consumers is not proportional to the difference in marginal costs (e.g. Stigler (1987) and Stole (2007)). Obviously, as in monopoly settings, under imperfect competition price discrimination is only feasible if the following conditions are satisfied: (i) firms must have some market power; otherwise the law of one price applies; (ii) firms must be able to segment consumers, either directly or indirectly (i.e. through the use of self selection mechanisms) and, (iii) firms must be able to prevent resale or, equivalently, arbitrage across differently priced goods must be prevented.[3]

In a recent paper, Fudenberg and Tirole (2000, p. 637) noticed that "...there are more forms of price discrimination than the standard typology suggests...". The standard typology of price discrimination forms goes back to Pigou (1920) and is the one adopted in almost all textbooks. Following Pigou there are three types of price discrimination. First-degree price discrimination arises when the firm is able to charge a different price per unit of product and per consumer, which under monopoly means that the firm is able to extract all consumer surplus. (We will see below that under competition first-degree price discrimination will in general leave some consumer surplus.) Most recently, economists have defined second-degree price discrimination as the practice of discriminating on the basis of unobserved consumer heterogeneity. Thus, the firm offers a menu of products and prices and consumers self-select into the appropriate niche of the market. Lastly, under third-degree price discrimination, perhaps the most evident form of price discrimination, the firm can discriminate on the basis of observable and verifiable consumer characteristics (e.g. past purchasing decisions, age, gender, geographical location, etc.). In the context of the new information markets, Shapiro and Varian (1999) recover the Pigou's terminologies of price discrimination but give them different designations, respectively: (i) *personalised pricing:* sell to each customer at a possibly different price; (ii) *versioning*: offer a product line and let users choose the version of the product most appropriate for them; and (iii) *group pricing*: set different prices for different groups of consumers.

Latest work on price discrimination has pointed out new ways of categorising different forms of price discrimination. Armstrong and Vickers (2001) notice that price discrimination may take the form of *interpersonal* discrimination or *intrap-*

[3] Some of the mechanisms firms can use to prevent resale can be found in Carlton and Perloff (1994).

*ersonal* discrimination.[4] This classification is based on whether firms discriminate across consumers or across units for the same consumer. Interpersonal price discrimination is present when *different* consumers face different price-marginal cost ratios (i.e., the variation in prices is across consumers). Using the *Amazon*'s story example when it charges different prices to loyal and first-time consumers it is able to sort the consumers into different segments and charge each segment a different price. In doing so, the firm is using interpersonal price discrimination. In contrast, intrapersonal price discrimination is present when the *same* consumer faces different price-marginal cost ratios across the portfolio of goods purchased. When *Amazon* sends a given loyal consumer a special e-mail promotion for a particular book plus a DVD that does not correspond to the price that same consumer would pay if buying separately each of the goods, it is using intrapersonal price discrimination.

As well as categorising price discrimination strategies as either interpersonal or intrapersonal, Stole (2007) claims that it is also useful to categorise price discrimination strategies according to whether the form of consumer heterogeneity is observable or not. In this regard, price discrimination is either *direct* or *indirect*. Direct price discrimination arises when price discrimination is based on some observable demand related characteristic (e.g. third-degree, location based, behaviour-based, etc.). In contrast, indirect price discrimination arises if consumer heterogeneity is not directly observable and firms need to rely on self-selection mechanisms to indirectly separate consumers (e.g. nonlinear pricing).

Finally, within the terminology of direct and interpersonal third-degree price discrimination, we present a new form of price discrimination in which firms offer different deals (e.g. prices, discounts or coupons) to its own customers and to the rivals' previous consumers. Indeed, it is generally the case that firms offer better deals to those consumers that bought from rival firms before. Broadly speaking, the main goal of this marketing strategy is to generate profitable incremental sales without damaging the profits a firm can extract from its own customer base. While Chen (1997) calls this strategy *paying customers to switch*, Fudenberg and Tirole (2000) call it *customer poaching*.

In light of the above, this survey will address the profit, consumer surplus and welfare implications of direct and interpersonal price discrimination in competitive settings. In the subsequent study a dichotomy is established. We begin with those papers that have focused on price discrimination strategies in static frameworks. Within this class of works we will examine models where firms have the required information to price discriminate on an individual basis (i.e., first-degree price discrimination) and on a segment basis (i.e., third-degree price discrimination). Afterwards, we will examine a relevant class of models that have extended third-degree price discrimination to dynamic settings. In this latter case, price discrimination is based on information about consumers' past purchasing behaviour.

As usual in the literature, the evaluation of the economic effects of price discrimination will be discussed in relation to the benchmark case where price discrimination is for any reason not permitted. In other words, we will compare profits, con-

[4] Because this survey will not focus on intrapersonal price discrimination the interested reader may look at Armstrong and Vickers (2001) for a detailed discussion of this form of price discrimination.

sumer surplus and welfare when departing from a setting where firms set uniform prices to one where price discrimination is introduced.

## 3 Competitive Price Discrimination in Static Settings

As was once suggested by Louis Phlips (1988, p.18) in his book on *The Economics of Price Discrimination*, "If you can discriminate, it is profitable to do so. (...) a discriminating price policy is at least as profitable as a nondiscriminating one."

While this basic principle is widely accepted for a monopolistic firm with market power we will see that this may no longer be the case in an imperfect competitive setting. Under monopolistic price discrimination the only effect at work is the *surplus extraction effect,* through which price discrimination allows the seller to extract more consumer surplus than it could extract under uniform pricing. In contrast, when we introduce competition into the market this is no longer the case, as each firm needs to take into account the strategic effects of its actions. In competitive settings there is another effect at work, namely the *business stealing effect*. According to this latter effect, in competitive environments price discrimination may act to intensify competition. Whereas the *surplus extraction effect* tends to increase profits the *intensified competition effect* tends to reduce them. Thus, whether profits fall or rise with discrimination depends upon which effect dominates. As will be explained the final outcome depends in turn on the specificity of markets.

The literature on price discrimination in competitive settings is not as extensive as that under monopoly settings. One very important model to assess the competitive effects of price discrimination is that proposed by Thisse and Vives (1988). They consider a standard Hotelling (1929) duopoly model of spatial price discrimination, where the two firms directly observe the location of each consumer on a linear market. Thus, direct price discrimination is implemented if firms can base their prices on consumer location. Additionally, since firms set their prices on a consumer's location basis this is clearly an example of first-degree price discrimination. In this framework, Thisse and Vives show that price discrimination acts to intensify competition in each location. Like in Lederer and Hurter (1986), Thisse and Vives show that the best price the more distant firm may set in equilibrium is the marginal cost, and that the closest firm needs to provide the same utility level in order to make a sale. As a result of that, they show that *all* prices might fall in relation to uniform pricing. To be precise, if the distribution of consumers is uniform and includes the end points of the market then all prices fall down except the price charged to consumers located exactly at the mill, which remain unchanged.[5]

[5] Although the Thisse and Vives model has been usually referred as a model where under competition price discrimination leads all prices to fall, the reader should take into account that this result is specially true when consumers are uniformly distributed say on the interval $[0,1]$. It is important to say that the Thisse and Vives model does not always reduce all prices with discrimination. The interested reader may consider the following two examples. First, assume each consumer has an observable location $x$ uniformly distributed on the interval $[0,1]$, transport cost is $t$ and marginal

In contrast, price discrimination by a multiplant monopolist would lead to increased prices and profits relatively to uniform pricing.

Therefore, in this duopoly model moving from uniform pricing to a discriminatory pricing policy leads to more aggressive pricing in every location, and thereby all prices fall as well as profits.[6] Since the intensified competition effect is clearly the dominant one, firms are worse off with the ability to price discriminate. As this model deals with unit inelastic demands and the market is always covered in equilibrium, conclusions regarding the consumer surplus and welfare effects of price discrimination are straightforward and immediate. As prices fall to every consumer, it immediately follows that consumer surplus is higher with price discrimination. However, because all consumers buy one unit of product either under uniform pricing either under discrimination, and all consumers buy from the closest firm in both regimes, welfare is not affected by the ability of firms to price discriminate.

Going back to the second question we have stated in the beginning of this survey, as competitive price discrimination intensifies competition and leads to lower profits, it is natural to wonder whether firms may have an incentive to avoid price discrimination, perhaps through commitments to uniform pricing. This type of concerns was also present in Thisse and Vives's (1988) analysis, who investigate whether firms may find individually optimal to avoid price discrimination by committing publicly to uniform pricing. To address this issue they add an initial stage in which each firm may decide to commit to uniform pricing or not. In the second stage, both firms observe any first stage commitments and set their prices accordingly. Interestingly, they show that when firms commit publicly to any of the two pricing policies, price discrimination is always a dominant strategy, and thereby firms find themselves in the well known Prisoner's dilemma—both firms would like to commit collectively to uniform pricing but individually price discrimination is a dominant strategy. (This result is not a surprise as all else equal each firm prefers to use more instruments rather than fewer (see Phlips (1988).)

More recently, stimulated by advances in information technologies some researchers have extended the Thisse and Vives's (1988) model to analyse the competitive effects that arise when firms can tailor special prices, discounts or coupons either to individual customers or to specific consumer segments.

Ulph and Vulkan (2000), for instance, have recovered the Thisse and Vives's model to investigate whether it is in the interest of firms to set personalised prices (i.e. to first degree price discriminate) in the context of e-commerce markets. The

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production costs are null. It is well known that without discrimination the equilibrium price is $t$. Second, consider the same assumptions as before but now suppose that consumers are distributed on $[0,1]$ with density $f(x) = 6x(1-x)$. In this case, the reader may confirm that the equilibrium price without discrimination is $\frac{2}{3}t$. Since in both examples prices with discrimination do not depend on the distribution and belong to the interval $[0,t]$ it immediately follows that in the first example the discrimination prices are below the non-discrimination price. In contrast, in the second example, the no discrimination price is between the discrimination prices. Thus, in this latter case price discrimination does not reduce all prices.

[6] Esteves and Pinto (2009a) extend the Thisse and Vives model to a framework where each firm's production cost is its private information. They investigate the profit and consumer effects of price discrimination in a model where firms act as bidders in an auction.

main difference between the two models is that Ulph and Vulkan use a general transport cost technology, which has the linear one used by Thisse and Vives as a special case. Additionally, they replace the location interpretation by any form of product differentiation (e.g. brand loyalty). For the Thisse and Vives reasons, they find that it is generally the case that price discrimination leads to lower profits for both firms. Particularly, they show that if some consumers are very loyal and some do not, then although discrimination can lead to higher prices to most loyal consumers it leads to lower prices to those consumers located in the middle. Even when firms are able to appropriate some consumer surplus due to discrimination, this may not be enough to overcome the negative effects of intensified competition. They show that only when there is a bias towards very strong loyalty will discrimination improve profits. (Only when most consumers are strong loyal to one of the firms will the surplus extraction effect dominate the intensified competition effect, thereby allowing profits to rise.)

Let us turn now to direct and interpersonal third-degree price discrimination in environments of imperfect competition. A relevant article shedding some light on the price, profits and consumer welfare effects of this form of price discrimination in oligopoly models with product differentiation is Corts (1998). Following Corts there are two distinct models of price competition with product differentiation. While some markets exhibit *best-response symmetry* others exhibit *best-response asymmetry*. Best-response symmetry is present when the "strong" and the "weak" markets of each firm coincide.[7] In contrast, best-response asymmetry is present when the weak and the strong market of each firm differ (i.e., when one firm's weak market is the other's strong market and vice-versa). Particularly, he shows that in models exhibiting best-response symmetry, the uniform price lies between the two discriminatory prices. Like in monopolistic models of third-degree price discrimination, the welfare effects of price discrimination in models displaying best-response symmetry is in general ambiguous.

Conversely, he demonstrates that when one firm's weak market is the other's strong market unambiguous price, profit and consumer welfare effects may arise. Regarding the effects of price discrimination on prices, he shows that it is possible that all prices fall with price discrimination—which he designates as *all-out competition* result—or all prices rise—which he terms as *all-out prices increases*. As a result of that, with all-out competition, price discrimination clearly leads to lower profits but higher consumer surplus. (With best-response asymmetry, all-out competition will in generally occur if price discrimination intensifies competition and the strategic complementarity of pricing is strong enough.) In contrast, with all-out prices increases, price discrimination has opposite effects: firms are better off while consumers are worse off. Nevertheless, it is important to say that even within best-response asymmetry the welfare effects are not immediately obvious. If with all-out competition aggregate output increases price discrimination is welfare improving. However, as will become clear below it may happen that welfare remains constant or even decreases with all-out competition. This latter result tends to occur in mod-

[7] Consider the existence of two markets 1 and 2 and two firms A and B. Following Stole (2003), market 1 is firm A's strong market (whilst market 2 is its weak market) if, for any uniform price set by firm B, the optimal price in market 1 is always higher than the price in market 2.

els where there is no role for price discrimination to increase aggregate output and where price discrimination uniquely gives rise to *inefficient shopping* (e.g. when due to price discrimination some consumers buy from the more distant firm).

The Thisse and Vives's (1988) model presented above is, of course, an example of a market exhibiting best-response asymmetry. Indeed, this is in general the rule in models of price discrimination based on location: the far away market from one firm (i.e. its weak market) is the strong market for the other firm. We have seen that as price discrimination strongly intensifies competition in each segment all prices might fall down as well as profits, leading to all-out competition. However, because the market is completely covered and demands are inelastic we have seen that though consumers are clearly better off with discrimination, welfare remains constant. (Here when firms price discriminate all consumers buy from the nearest firm. Thus, there is no inefficient shopping.)

Notwithstanding this survey focus on models that exhibit best-response asymmetry, it is worth presenting the Holmes's (1989) article within the approach of best-response symmetry. He extends the Robinson's (1933) seminal article on third-degree price discrimination with monopoly,[8] to examine the profits and welfare effects of this form of price discrimination in a symmetric duopoly model with product differentiation.[9] Additionally, he provides a useful result to predict in which circumstances will aggregate output (and therefore welfare) increase or decrease with the introduction of price discrimination. Whether aggregate output will rise or fall with discrimination depends not only on the convexity-concavity properties of industry demands—as in monopoly—but also upon the ratio of market to cross-price elasticities, which stresses the effect of competition. Under linear demand functions he finds that when the elasticity ratio condition is satisfied profit as well as output (and welfare) increases. Conversely, when the elasticity ratio condition is violated while the effect on profits is ambiguous, welfare falls down with discrimination. More precisely, if in relation to the strong market, the weak market has a higher cross-price elasticity but lower market elasticity then profits are lower with price discrimination.[10]

Recently, Armstrong and Vickers (2001) propose a new framework to investigate the profits and welfare effects of interpersonal and intrapersonal price discrimination in competitive settings (i.e., they model firms supplying utility directly to consumers). Within the interpersonal approach they discuss a model similar to Holmes

[8] Robinson (1933) analyses a monopolist which third-degree price discriminates on the basis of weak and strong market segments. As usual under monopoly the price charged to consumers in the strong market is higher than the price charged to consumers in the weak market.

[9] In Holmes (1989) not only is the ranking of weak and strong markets symmetric, but own-price and cross-price elasticities are also identical.

[10] Let $\varepsilon_i^m$ be the market elasticity of demand and $\varepsilon_i^c$ be cross-price elasticity of demand in market $i = s, w$ where $s$ stands for strong and $w$ stands for weak markets respectively. Then when demands are linear, the elasticity ratio condition is satisfied if

$$\frac{\varepsilon_w^m(p_w)}{\varepsilon_s^m(p_s)} > \frac{\varepsilon_w^c(p_w)}{\varepsilon_s^c(p_s)}.$$

(1989). Particularly, they analyse a duopoly model where firms face two separate market segments, with each segment being a Hotelling market with uniformly distributed consumers and with distinct "transport costs". In this framework, they show that if there is enough competition (i.e., low enough transport costs), price discrimination increases profits and reduces consumer surplus and welfare. In this way, they suggest that the Holmes's (1989) result that profits may fall is a consequence of relatively uncompetitive markets. In light of the two previous models, as Stole (2007) notices, it can be said that there is a consensus that in settings exhibiting best-response symmetry it is very often the case that price discrimination increases profits.

Finally, we focus next on the aforementioned form of interpersonal direct third-degree price discrimination in which firms offer different deals (e.g. prices, discounts or coupons) to its own customers and to the rival's consumers.[11] In other words, each firm observes directly to which firm each individual consumer belongs and price discriminates accordingly. Clearly, this type of model exhibits best-response asymmetry.

While much of the work that has been produced in this form of price discrimination deals with dynamic settings (as we will see in the next section), Shaffer and Zhang (2000) propose a static model to investigate whether duopolistic firms should offer better deals to its own customers—i.e. follow a *pay to stay* strategy—or to the rival's customers—i.e. follow a *pay to switch* strategy. The model is static in the sense that they do not investigate how firms obtain the required information for price discrimination.[12] They consider a duopoly model where each firm faces two separate groups of consumers: its loyal customers and the rival's loyal customers. However, as they assume that one group's average loyalty may be higher than the other group's average loyalty, the model allows for asymmetric demands. Additionally, they assume that firms are asymmetric in size given that, all else equal, one firm has a higher initial market share. When the average loyalty of the two groups is not very dissimilar each firm's more (cross-price) elastic group is the rival's customers group, that is each firm's weak market is the other's strong market. In this case the model exhibits best-response asymmetry and each firm should pay customers to switch (i.e. offer a lower price to the rival's customers). As expected, they show that in a symmetric market (i.e. equal average loyalty across groups) both firms offer lower prices to the rival's customers; price discrimination intensifies competition thereby leading to all-out competition. In contrast, they show that if the average loyalty of the two groups is too dissimilar, then the firm which own customers are not

[11] For models where firms price discriminate among customers with different brand loyalties on the basis of coupons see, for instance, Shaffer and Zhang (1995). They find that price discrimination leads to a prisoner's dilemma.

[12] We will see in the next section that much of the literature on this kind of price discrimination looks at two-period models, in which consumers' purchases in the initial period reveal their preferences from one of the firms. Conversely, Shaffer and Zhang (2000) exclude any prior competition, and assume that firms are able to infer a consumer's preference on the basis of internal sources of information such as firm's transactions databases or from specialised information vendors. Therefore, it can be said that their model corresponds to the second period of models analysed in the ensuing section.

very loyal finds that group the more elastic one, and thereby it should pay customers to stay (i.e., offer a better deal to its own customers). Thus, while one firm charges a lower price to the rival's customers the other charges a lower price to its own customers. The profit effects of price discrimination are strongly dependent upon the relative loyalty and firm's size. Particularly, they show that if the firm, which has a larger baseline market share, follows a pay to stay strategy while the smaller firm follows a pay to switch strategy then it may happen that price discrimination may lessen price competition, thereby increasing the smaller firm's profits or even both firms' profits.

Finally, Esteves (2008) extends the Thisse and Vives (1988) model by assuming that each firm observes a (less than perfect) signal of a consumer's brand preference, and that one firm's signal is not seen by its rival. As expected it is found that when firms rely on very accurate information they behave more aggressively leading all prices and profits to fall. In spite of firms being able to raise their prices to consumers recognised as loyal, even when the signal is highly imperfect it is shown that firms are worse off if they have the ability to price discriminate. In this way, this paper puts forward that collectively it is not in the interest of firms to improve the quality of their information about customers, however a firm might individually prefer to do so.[13] Further, because consumers are expected to pay lower prices, the it is shown that consumers are strictly better off when firms recognise them more accurately while profits and welfare are unambiguously worse off.[14] Remarkably, this suggests that any public policy protecting consumer privacy by restricting customer recognition would benefit all competing firms but at the expense of consumer welfare. Additionally, Esteves (2008) lays out the conceptual issues that arise when firms price discriminate on the basis of public and inaccurate information. The results derived in this extension reinforce the idea that consumers clearly benefit when firms recognise them more accurately and in the same way given that this would lead to more aggressive behaviour and to lower expected prices for everyone. By contrast, profits and welfare move in an opposite direction. Extending the model to public information suggests that it is not in the interest of firms to share their private information with their competitors. However, it is in the best interest of consumers to allow firms to recognise them accurately. Paradoxically, the paper stresses that any regulation trying to restrict information sharing would most likely benefit firms' profitability and overall welfare but again at the expense of consumers.

[13] A similar result is obtained by Liu and Serfes (2004) who propose a model that encompasses perfect and imperfect price discrimination. They show that equilibrium profits are U-shaped in the precision of information about brand preferences: profit is lowest when the firms have information that is less precise than the perfect information in the Thisse-Vives framework.

[14] In his book *The Economics of E-commerce,* Nir Vulkan (2003) states that"...if firms cannot gain from perfect price discrimination, they have even fewer incentives to charge individual prices when they can discriminate only partially." The results derived in chapter 2 challenge Vulkan's conclusion as they suggest that firms are unequivocally better off when they only have the ability to price discriminate imperfectly.

## 4 Competitive Price Discrimination in Dynamic Settings

This survey has focused so far on competitive price discrimination in static settings. However, as aforementioned a new price discrimination tool has become available for firms, namely each consumer's purchasing history. As firms become able to recognise its previous customers they can offer different prices to old and new customers, which clearly is a kind of dynamic (direct and interpersonal) third-degree price discrimination.

Whereas static settings are a useful framework to investigate how price discrimination, based for instance on consumer-specific information, will affect firms' profits and welfare, they are silent about any prior competition and about the dynamic effects of price discrimination. When firms price discriminate by observing each customer past purchasing behaviour some interesting questions arise. First, how can firms obtain the required information for price discrimination? Second, as firms foresee the future effects of price discrimination enabled by customer recognition, will they change their current pricing behaviour? Are first-period prices above or below the non-discrimination levels? Third, what are the overall profit, consumer surplus, and welfare effects of price discrimination? These and other related issues have given rise to a series of papers in which firms offer different deals to customers with different past behaviour profiles.

Different approaches have been considered in the literature so far. In one approach purchase history discloses information about exogenous switching costs, in other approach purchase history discloses information about a consumer's exogenous brand preference. In the previous approaches consumers are perfectly informed and there is no role for advertising. A third approach assumes that advertising is needed to transmit information to otherwise uninformed consumers. Consumers are ex-ante identical regarding their preferences for the firms, however, in contrast to the switching costs approach, after advertising decisions have been made, some consumers are endogenously locked in with a certain firm, not due to the existence of switching costs, but rather because they ignore the other firm. A common feature in these approaches is that price discrimination can only be implemented after firms have observed the first-period actions of consumers (i.e., in the initial period consumers are anonymous). In what follows it is assumed that firms cannot commit themselves in the first period to long-term prices.[15]

### *4.1 Homogeneous Products and Exogenous Switching Costs*

The works within the switching costs approach are motivated by those industries where consumers often need to incur a switching cost if they decide to move from one supplier to another (e.g. due to the existence of subscription fees, transactions

[15] For an analysis of purchase history pricing with long-term commitment see Caminal and Matutes (1990) and Fudenberg and Tirole (2000, section 5).

costs or costs of learning to use a new product).[16] Despite the fact that goods are initially homogeneous, after purchase decisions have been taken, due to the existence of switching costs, consumers are in the next stage of the game partially *locked in* with their initial sellers. In this setting, when firms are able to recognise their own customers and to separate them from the rival's ones, they will try to entice the latter group of customers to switch by offering them a better deal.

The first set of models investigating dynamic third-price discrimination in markets with switching costs are Nilssen (1992), Chen (1997) and Taylor (2003).[17] Nilssen (1992) is the earliest discussion on third-degree price discrimination in a market with switching costs. However, his main goal is to discuss how two different types of switching costs—transaction costs and learning costs—affect the market outcomes.[18] A crucial feature of Nilssen's model is that because there is no uncertainty about the size of switching costs and all consumers are identical, in spite of firms offering discounts to entice consumers to switch no consumer actually switches in equilibrium.

The focus in Chen (1997) is to investigate the competitive effects of paying customers to switch. Particularly, he studies a two-period duopoly model with homogeneous products and where switching costs are uniformly distributed. After first period purchase decisions have been taken, each consumer is partially locked in with his current supplier. In the second period, by observing each consumer's past behaviour, each firm is able to recognise its own customers (i.e., its strong market) and to offer better deals to the rival's previous customers (i.e., its weak market). As both firms try to entice each other's previous customers the second-period market exhibits *all-out competition*: in comparison to uniform pricing, price discrimination lowers all segment second period prices,[19] raises consumer surplus and lowers profits. Furthermore, as firms realise that they can charge higher discriminating prices to its locked in customers base, they have an incentive to build market share. This in turn leads to first period prices *below* the non-discriminating counterparts. Indeed, in Chen's model first-period prices are even below marginal cost. As a whole, Chen shows that total profits with price discrimination are always lower than if price discrimination were not permitted. In spite of the consumer surplus effect of price discrimination is ambiguous, welfare is clearly higher without price discrimination. Of course, because aggregate output is constant, welfare is lower with price discrimination because it induces *inefficient switching*.

Finally, Taylor (2003) extends Chen's model to many periods and many firms. Like Chen, he finds that price discrimination is bad for profits and welfare. An interesting point in his analysis is that while in a duopolistic market firms earn pos-

[16] For a detailed survey of switching costs and their effects see Farrel and Klemperer (2007).

[17] The Shaffer and Zhang's (2000) model presented before also studies third-degree price discrimination in markets with switching costs. However, their model corresponds to the second-period of the models presented here.

[18] While transaction costs are incurred every time the consumer switches, learning costs are only incurred the first time the consumer uses a new brand.

[19] An interesting feature of Chen's model is that because a firm's old and new customers are in unconnected markets, second-period prices do not depend on market shares.

itive profits on its base of old customers as well as on its base of new customers, in markets with more than two firms, firms earn positive rents on their base of old customers but zero expected profits per new customer attracted.

In short, BBPD in markets with exogenous switching costs leads firms to charge first period prices *below* their non-discrimination counterparts and then to *raise* their prices once consumers are locked in. (In these models old (loyal) customers pay always higher prices than first time customers.) In general, profits and welfare are lower than if firms were unable to price discriminate.

### *4.2 Differentiated Products and Exogenous Brand Preferences*

The set of models that have analysed price discrimination based on consumer past behaviour within this second approach assumes that firms offer horizontally differentiated products (rather than homogenous products) and that there are no switching costs. Here the fact that a consumer chose a given firm's product in the past reveals to that firm, under certain conditions, that he has a preference for that product. It is worth noting that consumers' preferences should be unchanging (or at least correlated) over time; otherwise purchase history would be completely uninformative. Hence, if preferences are fixed across periods, by observing each consumer past behaviour decisions, each firm identifies in the next period two separate markets: its previous clientele (i.e. its strong market) and the rival's customers (i.e. its weak market). If price discrimination is permitted, each firm can try to poach those customers who have been revealed to prefer the rival's product by offering them lower prices. As mentioned before Fudenberg and Tirole (2000) designate this strategy as customer poaching.

The models that have analysed BBPD within the exogenous brand preferences approach are Villas-Boas (1999), Fudenberg and Tirole (2000), Esteves (2007) and Chen and Zhang (2008).[20]

Fudenberg and Tirole (2000) consider a two period version of the classic linear-city model in which consumers' preferences are distributed on an interval between the two firms serving the market. In the second period, firms *recognise* those customers that bought from them before and price discriminate accordingly. Thus, each firm will target the rival's previous customers with lower prices than its old customers. Again because each firm tries to poach each other's customers, price discrimination acts to intensify competition. Although loyal consumers pay higher prices than new customers, price discrimination intensifies competition thereby reducing both segment prices. As a result of that, consumers are better off but firms find themselves in the classic prisoner's dilemma. In contrast to the switching cost approach, Fudenberg and Tirole (2000) find that first-period prices are *above* the non-discrimination counterparts. (It is worth mentioning that if consumers were myopic first period prices would be the same regardless of whether or not customer

[20] For models of BBPD in a monopoly setting see, for instance, Fudenberg and Tirole (1998) and Villas-Boas (2004)

poaching is permitted.) The intuition for first-period prices above the static levels runs as follows. Given that non myopic consumers realise that second period poaching will give rise to lower second period prices, they become less elastic in period 1. Consequently, firms are able to quote higher first period prices than if poaching were not permitted. Thus, yet in contrast with the exogenous switching cost approach here prices *fall* over time. As a whole, price discrimination is bad for profits and welfare, though good for some consumers. Once more, because aggregate output is constant in both price regimes (i.e. uniform pricing and price discrimination) and because some consumers are effectively poached in equilibrium (i.e. each firm sells to some of the competitor's previous clientele), there is inefficient switching, which clearly is not good for social welfare.

Villas-Boas (1999) studies a related but infinite-period, overlapping-generations model in which firms can only price discriminate between loyal and first-time customers, which means that firms cannot distinguish between new and the rival's previous customers. As in Fudenberg and Tirole, he finds that price discrimination enabled by customer recognition leads to lower prices and profits. Further, he shows that as firms foresee the negative effects of price discrimination, which are greater the higher is the size of previous clientele, firms have less incentives to build market share, thereby competing less aggressively in the initial period. As a result of that first period prices are *above* the non-discrimination counterparts. Again because some consumers are in effect poached in equilibrium, price discrimination is bad for welfare and profits, but good for consumers.

Finally, Chen and Zhang (2008) revisit the profitability issue of BBPD using a discrete version of the Fudenberg and Tirole's two-period model. Specifically, they assume that each firm has an exogenous "loyal" captive segment of consumers who always buy from a particular firm as long as the firm's price is not above their reservation price, and who cannot be induced to switch. They further assume that there is a segment of price-sensitive consumers (or switchers) with a reservation value lower than the loyal customers' one, who always purchase from the firm offering the lowest price. Thus, firms compete only for switchers. In this framework, they show that by observing each customer past behaviour, firms might become able to know whether a consumer is a price sensitive or a captive customer. However, customer recognition will only occur if a firm's first-period price is high enough such that it is not accepted by all consumers. In doing so, they show that price discrimination based on purchase history will allow a firm to increase sales without damaging the profits it can extract from its locked in customers. A general result in their analysis is that second-period profits are higher with price discrimination. Hence, as price discrimination may benefit firms, they find that the pursuit of customer recognition motivates firms to price high in the first period, which in turn induces the rival firm to price less aggressively in that period. As a result, first-period prices are *above* their non-discrimination counterparts. It is worth mentioning that in contrast with Fudenberg and Tirole (2000), in this model first-period prices are above the non-discrimination levels even when consumers are myopic.[21]

[21] A similar result is obtained in Esteves (2009) which will be discussed in the ensuing section.

Esteves (2007) investigates the competitive and welfare effects of pricing with customer recognition in a duopolistic market where the distribution of consumer types is discrete. The use of a discrete distribution for consumer tastes brings new insights to the literature in the field and helps establish the idea that some of the competitive effects of BBPD and customer recognition do depend on what is learned about consumer demand, which in turn depends on the nature of preferences. This paper considers a repeated interaction model, where firms A and B market their goods directly to consumers whose preferences are determined by a binary distribution: half of consumers prefer firm A by a fixed amount and half of consumers prefer firm B by the same fixed amount. In online markets, for instance, it is likely that consumers' loyalty is limited, meaning that even though firms may have some advantage over their competitors due to brand loyalty, all consumers may, nevertheless, be induced to switch. There are only two periods so, being permitted, price discrimination can only occur in the second period when firms have learnt the consumer types by observing their first period choices.

A relevant contribution of this paper is to highlight the fact that firms may eschew learning the consumer types as a way to avoid subsequent price discrimination and a less favourable competitive outcome. It shows that when initial market shares are asymmetric (100-0 division) nothing is learnt about consumers, and subsequent prices and profits are higher. In contrast, with symmetric market shares, consumer types are fully revealed and second period prices and profits fall. Consequently, it is shown that forward looking firms have an incentive not to share the market in period 1, so as to avoid learning and therefore the negative effects of price discrimination. In relation to this second profit effect consideration, it is shown that firms price *below* the static or no-discrimination levels in period 1.[22] Given that the model predicts the existence of a bias towards asymmetric outcomes in period 1, the paper also investigates the circumstances in which an *asymmetric* pure strategy equilibrium could exist in the initial period, where the same firm serves the entire market. It is shown that there is sometimes an asymmetric equilibrium in the first period, where one firm sets a low price and captures all consumers while the rival finds it not profitable to match the low price firm because its profits will then be low in the second period. This finding suggests that in a many period game the uniform pricing could be sustained without any explicit collective action. Finally, the paper sheds light on the welfare effects of BBPD in markets where firms set prices randomly. A common prediction in the existing literature on BBPD is that price discrimination can be welfare reducing due to excessive switching (e.g. Fudenberg and Tirole (2000)). Here, in contrast, as random pricing tends to generate some inefficient shopping, price discrimination can act to increase efficiency.

[22] Fudenberg and Tirole (2000, p. 643) claim that the effects of behaviour-based price discrimination on first period prices in the brand preference approach are the reverse of those effects in the switching costs approach. Here, in contrast, we find that BBPD may lead to the same lower first period prices as in the switching costs approach.

### *4.3 Homogeneous Products, Advertising and Imperfectly Informed Consumers*

As aforementioned the literature on BBPD has hitherto focused on the assumption that firms can reach costlessly all potential consumers—i.e., on the assumption that there is no role for advertising and that consumers are perfectly informed. Esteves (2009) departs from this hypothesis by assuming that without advertising consumers are uninformed and firms have no demand. The paper addresses a two-period model with two identical firms advertising a new homogeneous product (and its price) to otherwise uninformed consumers. In period 1, each firm chooses what price to quote in its ads and an intensity of advertising that will be used in the current period as well as in the next one. After firms have sent their ads, *ex-ante* uninformed identical consumers will be differentiated on an informational basis. Some consumers will receive ads from both firms, will be *selective* (or price-sensitive) customers and will always buy from the lowest-priced known firm. Other consumers will receive ads from only one firm, will be *captive* customers and will buy from that firm provided that the price does not exceed the reservation value. Finally, some consumers will remain uninformed because they will receive no ads. In this setting, when a firm is in the market for more than one period, it may learn whether or not a previous contacted consumer bought its product. If a firm achieves that type of learning, it will face in the second period, two separate markets—that of its own customers and that of its rival's customers—and so it may be tempted to poach the rival's previous customers by sending targeted ads with lower prices to that group of customers. The paper shows that only the firm that advertises the higher first-period price will have information to employ BBPD in the second period. In period 1, the high-price firm sells only to consumers that are reached by its ads but not by the ads of the rival and therefore, using the list of people its advertisements have reached and the people who actually buy from it, the firm can, at the end of period 1, identify consumers who are aware of its product but have bought from the rival, and then offer them (targeted) price discount in period 2. The low-price firm in period 1 cannot make this distinction because all consumers reached by its ads buy from it. In period 2, the single discriminating firm, simply charges the monopoly price to its captive customers and competes in an unrestrained fashion with the rival firm over consumers that are aware of it but bought from the rival previously. In this competition, the non-discriminating firm is much less aggressive. This leads to an asymmetric mixed strategy price equilibrium in period 2 where the non-discriminating firm finds itself somewhat handicapped by its inability to price discriminate in order to properly protect its consumers from poaching by an aggressive (discriminating) rival firm. As forward looking firms anticipate higher second period profits due to discrimination, they have an incentive to price high in period 1 as a way to secure the discriminating position. This softens price competition in period 1, leading first-period prices to be (first order stochastic) larger than in the case of no discrimination. In contrast, to the extant literature (e.g. Fudenberg and Tirole (2000)), the model predicts that BBPD may lead at least some consumers to pay *higher* prices in both periods.

Regarding the profitability of BBPD, the main finding is that, when advertising costs are not too high, price discrimination boosts overall expected profits, regardless of the advertising technology in consideration. An interesting and novel result of the paper is that when advertising costs are high, there is more advertising with discrimination; when advertising is cheap, the reverse happens. The intuition for this result builds on the benefit of price discrimination. When discrimination is permitted each firm has dynamic incentives (i) to become the discriminating firm and (ii) to induce the non-discriminating firm to play *less* aggressively in the subsequent period. While the former goal is achieved by pricing strategically high in period 1, the latter goal is achieved by choosing a first-period advertising intensity that strategically increases the non-discriminating firm's captive segment. Thus, a relevant contribution of the paper is to highlight that in comparison to the no-discrimination case, the permission of BBPD leads firms to strategically alter their advertising choices in period 1 as a way to induce a softer behavior by the non-discriminating firm in period 2. For the same reason, it is shown that, unlike the no-discrimination case, neither firm chooses full market coverage when advertising is costless.

Finally, another theme of the paper is to investigate the welfare effects of BBPD in a market where consumers are not fully informed and where advertising is needed to generate demand. Under no-discrimination it is shown that firms choose the social optimal level of advertising. In contrast, with discrimination, it is shown that firms underadvertise when advertising is cheap, and they overadvertise when advertising costs are high. Apart from the special case where the advertising cost is such that price discrimination has no effect on advertising decisions, it is shown that BBPD is always bad for welfare. The profit and the welfare effects of price discrimination suggest that, at least when advertising costs are not too high, consumer surplus falls when discrimination is permitted. Thus, the paper highlights the importance of taking into account different forms of market competition when public policy tries to evaluate the profit and welfare effects of BBPD.

### *4.4 Remarks*

As behaviour-based price discrimination has gained popularity many interesting questions arose. Is it really in the best interest of firms to recognise customers with different past behaviour and to price discriminate accordingly? Or, is it rather in their interest to avoid any possible learning and thereby price discrimination practices? Should consumers hide their true types, i.e., should they behave anonymously? Further, should government regulation restrict information collection and price discrimination practices?

This survey has highlighted that conclusions regarding profit and welfare effects of price discrimination do depend upon the form of consumer heterogeneity, market structure and the available instruments for price discrimination. In imperfectly competitive markets exhibiting best-response asymmetry, it can be said that as long as both firms try to poach each other's customers, they will find themselves in the

classic Prisoner's Dilemma: even though firms would like to collectively commit to non-discrimination, individually price discrimination is a dominant strategy. When the exclusive effect of price discrimination is to give rise to inefficient switching—i.e. when there is no role for price discrimination to increase aggregate output—any public policy against price discrimination would be socially desirable if the emphasis were aggregate welfare. Of course, if the target were solely consumer surplus, in light of the above, price discrimination could prove to be in some circumstances desirable.

As Fudenberg and Villas-Boas (2007) argue research on BBPD has so far just uncovered the "tip of the iceberg" and so there is much work to be done in this topic in the future.

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