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Protecting Sticky Consumers in Essential Markets

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Abstract

This paper studies regulatory policy interventions that are aimed at protecting sticky consumers who are exposed to the risk of being taken advantage of. We model heterogeneous consumer switching costs alongside asymmetric market shares. This setting encompasses many markets in which established firms are challenged by new entrants. We identify circumstances under which such interventions can be counterproductive: with regard to the stated consumer protection objective and also with regard to the complementary aim to promote competition.

JEL classification: L11, L13, D4

Keywords: switching costs, price discrimination, uniform pricing, most-favoured customer clauses, price regulation, competition

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1 Introduction

The presence of sticky consumers who fail to switch to cheaper tariffs is arguably one of the most intractable issues that are faced by competition and consumer protection authorities in many market economies.[1] Such customer inertia has been observed in markets that involve utilities, including: retail energy; basic telecom services; and retail financial services such as current accounts or credit card accounts. These utilities provide essential services that every consumer must purchase to satisfy basic needs and to participate actively in economic and social life.[2] Consumers often show little preference for variety, so that competing offers are perceived as closely substitutable, as long as a minimum level of service quality and reliability is guaranteed. Therefore, the potential lock-in of consumers and the risk of their being taken advantage of are significant policy concerns.

Many of these markets have experienced entry by so-called "challenger" firms. Yet challenger firms typically face barriers to entry and expansion because of high customer acquisition costs that are due to customer inertia. And they risk that the make-up of their customer base is overexposed towards active customers who regularly shop around in their search for a better deal.[3] This gives rise to asymmetric market structures, in terms of market shares and switching costs – at least initially. This configuration, therefore, provides the typical background for regulatory intervention to reduce demand side frictions, with the dual objectives of protecting sticky consumers *and* promoting competition from "challengers".

In this paper, we study regulatory policy interventions that are aimed at protecting sticky consumers who are vulnerable to exploitation. We consider a setting in which two homogeneous-good producers with asymmetric market shares - a dominant firm and a challenger - compete for customers whose switching costs are heterogeneous, to the disadvantage of the challenger.[4] Heterogeneous switching costs allow us to distinguish between the firms' "front-book" – new, switching customers – and "back-book" – inert, locked-in customers.

We investigate how the distribution of demand-side frictions and market shares interact under various discriminatory pricing regimes that reflect recent regulatory proposals. We show that in our setting, while price discrimination benefits consumers by making an

[1]See, for example, Authority for Consumers and Markets (2014); Canadian Radio-television and Telecommunications Commission (2017); Competition and Markets Authority (2016a,b); Financial Conduct Authority (2015); Hortaçsu et al. (2017); OECD (2017).

[2]Competition and Markets Authority (2018); UNCTAD (2018). According to the Competition and Markets Authority (2018), "[e]ssential services refer to services that consumers need to participate in society and the economy, and where significant harm might arise if consumers are not able to access the service." The CMA lists in particular markets for mobile, broadband, cash savings, home insurance and mortgages.

[3] Authority for Consumers and Markets (2014); Financial Conduct Authority (2015).

[4]In Section 4.1 we make assumptions that ensure that the distribution of switching costs of customers of the dominant firm first-order stochastically dominates that of customers of the challenger.

oligopoly more competitive, regulatory remedies that promote disclosure and limit price dispersion dissipate much of these benefits. We also show that asymmetric regulatory interventions that are aimed at the dominant firm would tend to favour the challenger firm. And we argue that the dominant firm may use price discrimination as a means to deter entry by a challenger that lacks the ability to discriminate.[5]

The paper proceeds as follows: Section 2 lays out the policy background of our study and motivates the setup that we consider for our model. It also provides details on the pricing regimes that we consider in this paper. Section 3 connects our study to the large existing literature on price discrimination. Section 4 formalises our modelling framework and its underlying technical assumptions. Within the framework of a model with given asymmetric market shares and heterogeneous switching cost distributions, section 5 presents results on the four pricing regimes that are central to this paper. Section 6 extends the framework to a dynamic model that endogenises the asymmetric market structure and the heterogeneous switching cost distributions. Section 7 concludes.

2 Institutional Background

2.1 Policy Context: Switching Cost and Consumer Inertia

Consumer inertia, segmentation into "front-book" and "back-book" customers, and assertions of subsequent "exploitation", are recurrent policy concerns.[6] From a competition policy perspective, sticky "back-book" customers are said to convey "unfair" competitive advantages to dominant firms because they are typically more profitable than "front-book" customers who are more active, regularly shop around in search for a better deal, and have lower switching costs.[7]

The distinction between "front-book" and "back-book" often emerges because firms set contract terms that translate into consumer switching costs. To motivate our setting with

[5] A challenger, at the point of entry, does not have a "back-book yet that would allow the sorting of customers.

[6] For example, in September 2018 the official consumer representative body in the UK submitted a "super-complaint" that called on the national competition and consumer authority – the Competition and Markets Authority (CMA) – to launch a cross-sectoral market study to investigate the allegation that disengaged customers who fail regularly to shop around end up being charged excessive prices across a number of essential services. For example, Citizens Advice (2018) found that 8 in 10 people are currently charged significantly higher prices for remaining with their existing supplier in one or more essential markets. Their best estimate of the individual cost of this "loyalty penalty" stands at almost £900 per year. The CMA considered a variety of remedies, such as: (i) limiting price differences through tying; (ii) requiring suppliers to upgrade inactive customers to their best tariff (i.e., the cheapest based on the specific consumption profile); and (iii) imposing an absolute price-cap.

[7] Productivity Commission (2018).

heterogeneous switching costs, consider balance transfer credit cards as an example: Credit card providers differ with regard to the terms that they offer on new accounts that are set up when consumers transfer existing balances from the old card to the new one. Such terms include: a balance transfer feel; the rate and its duration on the balance transferred; annual percentage rates (APRs); etc. The terms differ along multiple dimensions and are therefore hard to compare. More important, some aspects of the terms – notably APRs – typically differ depending on the consumer's "personal circumstances". So what consumers see when they shop around is only representative, but eliciting the precise terms that apply to the individual consumer is costly because it requires going through a screening process at the respective banks, and it may be even costlier for consumers with subprime credit histories.[8]

Another example is overdraft facilities on current accounts: Before a customer switches banks, it is usually impossible to find out what the terms of an overdraft facility – limit and fees – will be. This is a particularly acute concern for "overdraft prisoners": consumers who excessively used their existing overdraft facility or are in breach of their current overdraft limit and consequently find it very difficult to switch.

Compounding the issue of customer inertia that creates entry and expansion barriers, incumbents can often identify locked-in consumers and take advantage of them by means of discriminatory strategies. The combined effect of the initial asymmetry of market shares and the potential to take advantage of a large portion of locked-in consumers suggests potentially very large consumer detriment.[9]

2.2 Price Discrimination and Regulatory Responses

One discriminatory strategy for the incumbent is behavioural-based price discrimination (BBPD) in order to stifle the growth of "challenger" firms or deter entry altogether (Chen, 2008). One form of BBPD is history-based price discrimination (HBPD), whereby firms offer separate poaching prices to rivals' customers, typically at a discount off the price that is paid by existing customers, and to the relative disadvantage of the retained customers.[10] Under HBPD firms are engaged in a Bertrand-type process of poaching each others poachable customers. In most circumstances - albeit not all, as we will show - the inert "back-book"

[8] Subprime customers tend to be less financially literate consumers; e.g., Gerardi et al. (2010) show a negative correlation between financial literacy and mortgage delinquency and default (i.e. subprime status). Agarwal et al. (2020) put forward an alternative explanation: Subprime borrowers tend to search less and accept higher borrowing rates because they are concerned about making too many applications that will be rejected, which would worsen their credit profile even further.

[9] Competition and Markets Authority (2016a,b); Hortaçsu et al. (2017).

[10] See, for example, Financial Conduct Authority (2017) and Competition and Markets Authority (2016b), para 8.232ff, which provides evidence of price discrimination between new start-ups and established businesses with respect to business current accounts.

customers will be charged higher prices than are the poached customers. While this may seem to be "unfair" to the former, it is the outcome of a competitive process. We study HBPD in section 5.1.

A number of consumer protection interventions have been considered by regulatory authorities, with the aim of restraining price discrimination and dispersion. Efforts to restrict price competition for the poachable customers will generally mean higher prices for most or all customers, because these interventions soften competition. This is seen most clearly when price discrimination is banned altogether and prices are required to be uniform: With uniform prices (UP), when a firm considers offering a low price so as to attract its rival's customers, the firm has to take into account that it will have to cut the price to all of its own customers as well. That makes the strategy of offering a lower price much less worthwhile in the first place. We compare UP with HBPD in section 5.2.[11]

In recognition that banning price discrimination tends to raise prices, intermediate pricing regimes have been proposed. One regime that we consider is HBPD with a disclosure requirement to offer the poaching price also to existing back-book consumers. We call this HBPD with leakage, as the lower poaching price leaks from the front-book into parts of the back-book.[12] Another intermediate regime is to constrain the dispersion of discriminatory prices, by pegging the magnitude of discounts to the level of the regular, undiscounted price; this constrains the ratio of the discounted to the regular price, so we refer to it as ratio-based price discrimination.

We evaluate the intermediate regimes in sections 5.3 and 5.4, respectively. Intermediate restrictions of leakage-encouragement or pegging also inhibit price competition, but not as severely as does the uniform price requirement. A leakage-encouragement essentially requires that the lower price be offered as an option to the back-book customers: Some of

[11]Uniformity of prices can also be achieved by means of most-favoured-customer-clauses (MFCCs). These discourage firms from cutting prices selectively, thereby inhibiting competition. See Akman and Hviid (2006) for a discussion of MFCCs from the perspective of competition law. MFCCs have been considered by Besanko and Lyon (1993). In their analysis, they treat MFCCs as an insurance for customers, in the sense that the firm that adopts an MFCC cannot discriminate among customers and must charge the same price to all customers.

[12]It could be argued that HBPD that is subject to disclosure effectively resembles most-favoured-customer clauses (MFCCs) when consumers face heterogeneous "hassle" costs to enforce their right to have their current service provider match the lower price that is offered to other (potentially new) customers. In our analysis, MFCCs amount to a form of third-degree price discrimination. They are treated as an option that is offered to existing customers that those customers may or may not exercise – depending on their idiosyncratic inertia. This is motivated, for example, by features of the UK cash savings market, where providers report that informing existing customers about better accounts with higher interest rates generates only a small response in (internal) switching (Financial Conduct Authority (2015), Annex 1.2). A difference between the model of Besanko and Lyon (1993) and ours is that our model determines inert, locked-in customers endogenously, while in the model of Besanko and Lyon (1993) the number of "non-shoppers" is exogenously given.

them will take the lower price, which again makes the initial action less worthwhile. And, similarly, to the extent that there is a binding limit (peg) on the ratio of poaching price to the undiscounted price, competition is again restrained.

It may be worth emphasising that these regulatory efforts to restrain poaching-pricing should not be confused with efforts to make a firm's customers more "poachable" by rivals, which will generally toughen competition and benefit consumers. For example, the CMA's Open Banking initiative aims at spurring competition in financial services through facilitating access to consumers, by enabling consumers and SMEs to share their bank and credit card transaction data securely with trusted third parties that are then able to provide them with applications and services that save consumers time and money.

To the contrary, the regulatory interventions that are investigated in this paper may be contentious from a competition policy perspective. For example, on the one hand, it is well-established that the use of HBPD under oligopoly can intensify pricing rivalry where competing firms exhibit best-response asymmetry, in that they hold opposing views as to which consumers are "strong" and which are instead "weak" (Armstrong, 2006). On the other hand, the use of HBPD by the dominant firm may be part of an exclusionary anticompetitive strategy that is aimed at foreclosing a potential entrant whilst mitigating the entailed profit sacrifice (Chen, 2008; Fumagalli and Motta, 2013; Gehrig et al., 2012; Karlinger and Motta, 2012).

The investigation of the implications of discriminatory pricing on competition with asymmetric market shares is policy relevant because, at least in Europe, the abuse of market dominance is an issue, in light of Article 102 of the Treaty on the Functioning of the European Union, only if the firm in question holds a dominant position.[13]

3 Related Literature

Our paper builds on the setting of Chen (1997), but adopts a more general model for continuous switching cost distributions than Chen (1997) does. Our (and Chen's) modelling approach goes beyond the standard approach in the theoretical industrial organisation literature on how behavioural biases affect market outcomes; that approach simply partitions consumers into "sophisticates" and "naifs" (e.g., Armstrong (2015); Armstrong and Vickers (2019); Heidhues and Kőszegi (2017)). In section 2.1 above, we provided a substantive contextual interpretation of and justification for our modelling assumption of continuously

[13] Baker and Salop (2015) advocate a similar approach, stating " U.S. antitrust law could do more to address inequality if the antitrust laws also addressed monopolistic "exploitative" conduct along the lines of the European prohibition against abuse of dominance".

distributed switching costs.

Both our analysis and that of Chen (1997) compare price discrimination when markets can be segmented with uniform pricing. As such, these analyses form part of a large literature that recognises that price discrimination can be a means to toughen oligopolistic competition. Armstrong (2008) and Stole (2007) provide comprehensive overviews of this literature.

Our framework is related to Gehrig et al. (2012), who study the welfare implications of HBPD under asymmetric market shares with horizontally differentiated products.[14] We prefer instead to abstract from product differentiation and heterogeneous brand preferences to model competition in "essential markets".[15] We decided to cast our analysis in terms of welfare-reducing heterogeneous switching costs, rather than welfare-enhancing brand preferences, because – in the typical essential markets that were subject to regulatory scrutiny and that contextualize our study – brand preference does not appear to play a significant role.[16]

We prefer to use a heterogeneous-switching-cost rather than product-differentiation approach because the latter does not fit the context of essential markets. In the Hotelling linear duopoly model of product differentiation and horizontal brand preferences, loyal customers are the ones paying the lowest 'delivered' price, inclusive of the 'transport' cost; marginal consumers that firms compete over are located farther away from either firm and pay a higher 'delivered' price.[17] In contrast to this, the main competition concern in the context of essential markets with customer inertia is that loyal "back-book" customers arguably are the ones being "exploited" and pay higher prices, compared to marginal, "front-book" customers.

Another feature of the Hotelling model of horizontal differentiation that does not fit the stylised facts is that a firm with the smaller market share is protected from the risk of further customer "poaching" thanks to the fact that the make-up of its customer base is dominated by very loyal customers who face very high "transport" costs vis-à-vis the rival firm. This

[14] Holmes (1989) investigates symmetric differentiated product oligopolies and shows that uniform prices necessarily lie between discriminatory prices. Corts (1998) relaxes Holmes' symmetry assumption and shows that, when firms differ in their assessment of their weak and strong markets, price discrimination can lead to all-out competition that benefits all consumers.

[15] Armstrong and Vickers (2019) adopt a similar approach, although they stick to the standard "sophisticates" vs "naives" partition and also do not model the presence of an incumbency advantage in terms of asymmetric market shares.

[16] For example, a 2014 YouGov survey of banking customers concludes that few people display unwavering loyalty to their provider, and two in five banking customers state that they would consider switching their account to another provider. Similarly, a GfK survey that was conducted in the course of the CMA's 2016 energy market investigation found that, with electricity being a homogeneous product, no factor other than price was relevant to energy customers.

[17] See, for example, Bester and Petrakis (1996). Esteves (2014) studies brand preferences in a dynamic duopoly model.

is in contrast to the view that "challenger" firms, which start by definition with very small market shares, might be over-exposed to the dominant firms' "front-book" customers who are intrinsically active switchers.

Accordingly, our approach is to model differentiated consumers rather than differentiated products: consumers' heterogeneous switching costs rather than brand preferences. Our framework is closest to Shaffer and Zhang (2000), who allow for heterogenous switching costs, distributed according to a uniform distribution with common minima equal to zero, and asymmetric baseline market shares.[18] However, we do not impose restrictions on the type of distribution and minima and also study additional pricing regimes, HBPD with leakage and with a peg, besides HBPD and UP.

4 Model Setting and Assumptions

We start by laying out our assumptions on our homogenous-good duopoly model. The model has two asymmetries: Each firm's customers exhibit a distribution of switching cost – customers have heterogeneous switching costs – and these distributions differ across firms; and the two firms have asymmetric market shares. In Section 5, we explore a series of pricing regimes within this setup in a static model in which the dominant firm – with a larger market share – has a customer base whose switching costs tend to be higher than those of the customers of the smaller, challenger firm. In Section 6.4, we discuss how this asymmetric market structure can be endogenised.

4.1 Heterogeneous Switching Costs

Suppose customers, with a total mass of unity, purchase a homogeneous product produced by one of two firms: A and B.

Customers of firm A have switching costs s_A that are distributed with CDF $F_A(s)$ for $s \in \mathcal{S}_A \subseteq \mathbb{R}_+$, and customers of firm B have switching costs s_B with CDF $F_B(s)$, $s \in \mathcal{S}_B \subseteq \mathbb{R}_+$. We assume that $0 = \min\{s : s \in \mathcal{S}_A\} = \min\{s : s \in \mathcal{S}_B\}$. Our setting allows for heterogeneity of the distribution of switching costs of the two firms' customer bases, except when $\mathcal{S} = \mathcal{S}_A = \mathcal{S}_B$ and $F_A(s) = F_B(s)$ for all $s \in \mathcal{S}$. Firms do not observe their or their rival's customers' switching costs, but they know their respective distributions. We assume that both CDFs are continuously differentiable so that their pdfs $f_A(s)$ and $f_B(s)$ exist.

We make the following assumption:

[18] Caillaud and De Nijs (2014) provide a dynamic version of Shaffer and Zhang (2000).

Assumption 1: (*Monotone Likelihood Ratio, MLR*)

$$f_A(s)f_B(t) - f_A(t)f_B(s) \geq 0 \ \ \forall s \geq t.$$

The MLR assumption has been discussed and used widely in microeconomic theory (Athey, 2002; Karlin et al., 1956; Lebrun, 1998; Maskin and Riley, 2000).

The MLR assumption implies that the distribution of firm A's customers' switching costs F_A first-order stochastically dominates that of firm B's customers' switching costs, i.e. $F_A(s) \leq F_B(s)$ for all $s \in \mathcal{S}_A \cup \mathcal{S}_B$.[19] It also implies that $\mathbb{E}[s_A] \geq \mathbb{E}[s_B]$.[20] So the setup allows for firm A's customers to be more likely to have higher switching costs than firm B's, and thus for their average switching costs to be higher. In other words, the model allows for firm A's customers to be more likely to be locked-in than are firm B's customers.

Furthermore, the MLR assumption implies the hazard rate (H) inequality:[21]

$$\frac{f_B(s)}{1-F_B(s)} \geq \frac{f_A(s)}{1-F_A(s)} \ \ \forall s \in \mathcal{S}_A \cup \mathcal{S}_B.$$

Similarly, the MLR assumption implies the reverse hazard rate (RH) inequality:[22]

$$\frac{f_A(s)}{F_A(s)} \geq \frac{f_B(s)}{F_B(s)} \ \ \forall s \in \mathcal{S}_A \cup \mathcal{S}_B.$$

We make the following second assumption:

Assumption 2: (*Log-Concavity*) The densities $f_A(s)$ and $f_B(s)$ are log-concave.[23]

The implications of assuming log-concave densities have been discussed in Bagnoli and Bergstrom (2005). They include that:

(i) the cumulative distribution functions $F_A(s)$ and $F_B(s)$ are log-concave;

(ii) the hazard rates $\frac{f_A(s)}{1-F_A(s)}$ and $\frac{f_B(s)}{1-F_B(s)}$ are monotonically increasing; and

(iii) the reverse hazard rates $\frac{f_A(s)}{F_A(s)}$ and $\frac{f_B(s)}{F_B(s)}$ are monotonically decreasing.[24]

[19] This follows from rearranging, integrating w.r.t. t over $\mathcal{S}_A \cup \mathcal{S}_B$ and then integrating up to s. It is obvious if $\sup \mathcal{S}_B \leq \inf \mathcal{S}_A$.

[20] This follows from $f_B(t)sf_A(s) \geq f_A(t)sf_B(s)$, integrating w.r.t. s and t over $\mathcal{S}_A \cup \mathcal{S}_B$.

[21] This follows from rearranging and integrating w.r.t. t up from s. This inequality implies that the model allows, for any s, that firm A's demand exhibits a lower own-price elasticity than does firm B's demand.

[22] This inequality, in turn, implies that, for any s, firm A's demand lost to firm B exhibits a higher cross-price elasticity than does firm B's demand that is lost to firm A.

[23] Recall that a density $f(s)$ is log-concave if $\ln(f(s))$ is concave: if $f"(s) - \frac{(f'(s))^2}{f(s)} \leq 0$ for all s in the support of f.

[24] Property (i) follows from Theorem 1 of Bagnoli and Bergstrom (2005); property (ii) follows from their Corollary 2; and property (iii) follows from property (i).

We will make use of these in deriving the key analytical results of this paper.

4.2 Asymmetric Market Structure

Suppose that firm A's market share is $x_0 \in (\frac{1}{2}, 1]$ – firm A is the dominant firm – and B's market share is $1 - x_0$ – it is the challenger firm. We treat x_0, F_A, and F_B as predetermined, and we discuss in Section 6.4 how this market structure can be endogenised.

We also assume that firms have the same constant marginal cost – which we normalize to zero.[25]

As in Chen (1997), let q_{ij} denote the levels of historic demand at firm j that currently accrues at firm i, with $i, j \in \{A, B\}$. So when $i \neq j$, this is the demand that firm j loses when firm i poaches firm j's customers. We assume throughout that consumers' valuations for the homogeneous product exceed prices so that every consumer is served, and that consumers are price-takers.[26]

5 Analysis of Asymmetric Market Structure

In this section, we consider four pricing regimes: history-based price discrimination (HBPD); uniform pricing (UP); HBPD with leakage; and ratio-based price discrimination. We show that, in terms of a consumer protection authority's objective of low prices, in our setting HBPD dominates ratio-based price discrimination and HBPD with leakage, both of which in turn dominate UP.[27] And we discuss implications of these rankings for consumer welfare and competition.

5.1 History-Based Price Discrimination

In this subsection we develop the history-based price discrimination (HBPD) model. In this setting, firms can discriminate among customers based on their purchase history. Under our Assumption 1, customers have sorted themselves such that the dominant firm A's customers tend to have higher switching costs than those of the challenger firm B.[28]

[25]As we do not wish to consider cost efficiencies in our analysis, this is without consequence for our results. We will discuss extensions to asymmetric cost structures in section 6.1.

[26]In principle, our analysis applies to business-to-business relationships as well, as long as buyers face suppliers that make take-it-or-leave-it offers.

[27]Without restrictions on model parameters, no ranking in terms of pricing between ratio-based price discrimination and BHPD with leakage is possible. However, we will show that there is bi-directional customer switching between firms with the former, while there is only one-directional switching with the latter.

[28]We discuss in Section 6.4 how such sorted customer bases and the asymmetric market structure can arise endogenously.

Each firm chooses a price that it offers to all its incumbent customers and that will be paid by its retained, "back-book" customers – p_A and p_B – and it offers a discount – m_A and m_B – to those consumers who previously did not buy from it, but instead bought from its rival: its rival's "front-book" customers. A Nash equilibrium, relative to x_0, in discriminatory prices in our setting involves for each firm two strategic variables: firm-specific prices p for retained customers; and discounts m to these prices that are offered to customers poached from the respective rival firm, (p_A, p_B, m_A, m_B), where each firm takes its rival's prices as given.

Consider a customer of firm A: If the customer stays with firm A, he will face price p_A. If he switches to firm B, he will be charged B's poaching price – $p_B - m_B$ – and incur a cost of switching. Given these prices, firm A's and B's marginal customers who are just indifferent between staying or switching therefore have switching costs

$$\sigma_A = p_A - p_B + m_B. \tag{1}$$

$$\sigma_B = p_B - p_A + m_A. \tag{2}$$

Therefore, firm A can expect to retain a fraction $\Pr(s_A \geq \sigma_a) = 1 - F_A(\sigma_A)$ of its customer base x_0 –, these are its locked-in or back-book customers – and to lose a fraction $F_A(\sigma_A)$; a symmetric argument holds for firm B. Hence,

$$\begin{aligned} q_{AA} &= x_0 \Pr(s_A \geq \sigma_a) = x_0 (1 - F_A(\sigma_A)) \\ q_{BA} &= x_0 F_A(\sigma_A) \\ q_{BB} &= (1 - x_0)(1 - F_B(\sigma_B)) \\ q_{AB} &= (1 - x_0) F_B(\sigma_B). \end{aligned}$$

Then, the firms' profits are given by

$$\begin{aligned} \pi_A(p_A, m_A; p_B, m_B) &= p_A x_0 (1 - F_A(\sigma_A)) + (p_A - m_A)(1 - x_0) F_B(\sigma_B) \\ \pi_B(p_B, m_B; p_A, m_A) &= p_B (1 - x_0)(1 - F_B(\sigma_B)) + (p_B - m_B) x_o F_A(\sigma_A). \end{aligned}$$

After straightforward algebra, it follows that the firms' profit maximization problems yield the following first-order conditions for an interior solution:[29]

$$
\begin{aligned}
p_A^D &= \frac{1-F_A(\sigma_A^D)}{f_A(\sigma_A^D)} && (3)\\
p_B^D &= \frac{1-F_B(\sigma_B^D)}{f_B(\sigma_B^D)} && (4)\\
p_A^D - m_A^D &= \frac{F_B(\sigma_B^D)}{f_B(\sigma_B^D)} && (5)\\
p_B^D - m_B^D &= \frac{F_A(\sigma_A^D)}{f_A(\sigma_A^D)}, && (6)
\end{aligned}
$$

where: p_i^D and m_i^D denote firm i's optimal price and discount; and $\sigma_i^D = p_i^D - p_j^D + m_j^D$, $i, j \in \{A, B\}$ and $i \neq j$. The first-order conditions show that the firms' discounted prices – $p_i^D - m_i^D$ – are set with respect to its rival's "front-book", i.e. with respect to the rival firm's customers' switching cost distribution. Thus, they serve as poaching devices to induce the rival firm's customers to switch.

The respective marginal customers that are being poached have switching costs σ_i^D that satisfy

$$
\begin{aligned}
\sigma_A^D &= \frac{1-2F_A(\sigma_A^D)}{f_A(\sigma_A^D)} && (7)\\
\sigma_B^D &= \frac{1-2F_B(\sigma_B^D)}{f_B(\sigma_B^D)}. && (8)
\end{aligned}
$$

The marginal customers σ_i^D and undiscounted prices p_i^D are determined by the firms' "back-book" – their respective own customers' switching cost distributions – as a means of taking advantage of those customers' lock-in.

As in Chen (1997), the initial market shares x_0 and $1 - x_0$ do not matter for the firms' optimal strategy – unless the distributions of the customers' switching costs themselves are functions of the initial market shares.[30] This shows that Chen's original results are robust to distributions that satisfy our Assumption 1.

What is the reason for the irrelevance of x_0? With HBPD, both firms treat their home

[29] The derivation uses the fact that the first-order conditions with respect to m_A and m_B eliminate the derivative of the second summand in π_A and π_B with respect to p_A and p_B, respectively. Superscript D denotes the optimal values under HBPD.

[30] This could arise, for example, as a consequence of network effects. See, for example, the discussion in Farrell and Klemperer (2007). An alternative explanation could be that normally consumer inertia takes time to set in, so firms that have been active for longer are bound to have a larger stock of "back-book" customers and thus a larger customer base than is true for newer firms that can grow only gradually as they compete for the new cohort of unaffiliated consumers and manage to retain them long enough for them to mature into "back-book" customers.

turf – x_0 for firm A and $1 - x_0$ for firm B – as separate markets in which they compete in setting prices: p_A^D for A's "back-book" customers, and B's poaching price $p_B^D - m_B^D$ for A's "front-book" customers; and similarly, $p_A^D - m_A^D$ for B's "front-book" customers and p_B^D for B's "back-book" customers. In these markets, profits are linear in the respective market sizes x_0 and $1 - x_0$, respectively, and hence x_0 is irrelevant for the optimal pricing strategies which are determined by F_A – (3) and (6) – and F_B – (5) and (4) – respectively.[31]

Under our assumptions, we can obtain the following results:

Lemma 5.1. *Under Assumptions 1 and 2, the dominant firm A's back-book customers have higher switching costs than do the challenger firm B's back-book customers. Formally,* $\sigma_A^D \geq \sigma_B^D$.

The proof of Lemma 5.1, as are the proofs of all subsequent results, are in Appendix A. The lemma has the interpretation that firm A's marginal customer that firm B induces to switch has a higher switching cost than does firm B's marginal customer.

The preceding Lemma is useful in order to establish the following

Proposition 5.1. *Under Assumptions 1 and 2, the dominant firm A's back-book customers pay higher prices than do the challenger firm B's back-book customers; and the dominant firm offers larger discounts than does the challenger. Formally,* $p_B^D \leq p_A^D$, *and* $m_B^D \leq m_A^D$.

The result shows that, with heterogeneous switching costs, the firm with the larger locked-in customer base charges a higher price. At the same time, it must offer a larger discount to its price in order to induce its rival's customer to switch because these customers tend to have lower switching costs. The intuition is that with HBPD firms treat their respective home turf as separate market. Customers on firm A's turf are more locked in than customers on firm B's because the former tend to have higher switching costs. Therefore prices charged on firm A's turf are higher than prices on firm B's turf. As p_B^D is lower than p_A^D and firm B's discount m_B^D is set relative to p_A^D – while firm A's discount m_A^D is set relative to p_B^D – it follows that $m_B^D \leq m_A^D$.

It may be worth noting that, without further restrictions, it is possible that $m_B^D < 0$. The reason is that B's discounted price is set with respect to its rival's customers' switching cost distribution F_A, while its undiscounted price is set with respect to that of its own customers: F_B.[32] So there are circumstances where B's poaching price exceeds its regular back-book price. Loyalty rebates for existing customers are an example.[33]

[31] Indeed, it is straightforward to show that separate optimizations over the two markets – with respect to p_A and $p_B - m_B$ over A's customer base, and with respect to p_B and $p_A - m_A$ over B's customer base – yield the HBPD outcomes (3) – (6).

[32] It is easy to construct analytical examples that exhibit this feature. We thank Ken Hori for pointing this out.

[33] One sees loyalty discounts frequently across the retail landscape – at least in the U.S., most commonly

5.2 Uniform Pricing

Consumer protection agencies see the persistent exploitation of "back-book" customers by means of HBPD as problematic.[34] They traditionally rely on disclosure remedies to induce consumers to switch. Support for disclosure remedies has been waning, however, in light of evidence that the use of prompts and alerts is ineffective towards a core of "back-book" customers with high switching costs.[35] Accordingly, there are calls – on fairness grounds – for stronger remedial interventions that are aimed at directly restricting firms' ability to exploit "back-book" customers.[36]

A straightforward option would be to ban price discrimination altogether, so that firms are allowed to set only one price for all customers: existing as well as prospective ones.[37] This remedy effectively implements a uniform pricing regime for each firm.

With uniform prices, either some of firm A's customer switch – if firm A's uniform price exceeds firm B's uniform price –, or some of firm B's customers switch, but not both. Consider the first of these two cases. In this case, firm A's marginal customer is just indifferent between paying firm A's price p_A or firm B's price p_B and incurring the cost of switching to B. Hence, firm A's marginal customer's switching cost $\sigma_A = p_A - p_B > 0$.

in retail settings with repeat purchases and without contractual relationships: e.g. some U.S. supermarkets award loyalty points to " club" or special-card members. In this paper, we focus on essential services and hence on settings with contractual relationships. Here, loyalty schemes are aimed at compensating for existing lock-in. For example, some U.S. retail banks operate loyalty schemes, in line with customer spend or account balance; the earned points can be used for mortgage or student loan repayments; travel rewards; charity donations; etc.

[34]This concern is compounded to the extent that inert customers are often "vulnerable" due to certain demographic characteristics such as low income, old age or generally limited awareness (Competition and Markets Authority, 2016a, 2018; Financial Conduct Authority, 2018a).

[35] Adams et al. (2018); Financial Conduct Authority (2018b). For example, during the second half of 2015 the FCA tested the use of a return switching form where customers were sent a letter with an indication of potential gains from switching to the best internal rate (i.e., offered by the same provider) and the best competitor rate – based on a non-personalised balance example (£5,000) – plus a tear-off return switching form pre-filled for a switch to the best internal rate, along with a prepaid envelope. In the nine weeks following the receipt of the letter, internal switching increased from a baseline of less than 0.5% to slightly above 8.5%, whereas external switching hardly changed. See Adams et al. (2016)

[36]See Competition and Markets Authority (2016a); Financial Conduct Authority (2018a,b); UK Department for Business, Energy and Industrial Strategy (BEIS) (2018). The BEIS Consumer Green paper states (para. 41): "We believe there should be a new approach by government and regulators to safeguard consumers who, for whatever reason, remain loyal to their existing supplier so that they are not materially disadvantaged. Exploitation of these customers by charging them significantly higher prices and providing poorer service is a sign of a market that is not working well and should be tackled vigorously." See also "Victory for consumers as cap on energy tariffs to become law - New bill will protect millions more households from unfair price rises", UK Government, press release, 19 July 2018, available at `https://www.gov.uk/government/news`.

[37]A similar outcome would result from a requirement that firms automatically upgrade consumers to their cheapest available tariff. Although such a draconian intervention would normally be considered to be a sort of backstop remedy of last resort, the UK Financial Conduct Authority recently proposed this type of remedy twice: for savings accounts and for overdraft charges (Financial Conduct Authority, 2018a,b).

In this case, firm A only retains a fraction $1 - F_A(\sigma_A)$ of its customer base x_0, while firm B retains its entire customer base $1 - x_0$ and expects to gain a fraction $F_A(\sigma_A)$ of A's customer base. Hence, firms' expected demands are

$$\begin{aligned} q_A &= x_0 (1 - F_A(\sigma_A)) \\ q_B &= 1 - x_0 + x_0 F_A(\sigma_A). \end{aligned}$$

Only the distribution of switching costs of firm A's customers who have the option to switch matters in this case. The distribution of firm B's customers' switching cost is irrelevant.

The firms' profits are

$$\begin{aligned} \pi_A(p_A, p_B) &= p_A x_0 (1 - F_A(\sigma_A)) \\ \pi_B(p_A, p_B) &= p_B (1 - x_0 + x_0 F_A(\sigma_A)), \end{aligned} \tag{9}$$

and the first-order conditions for the firms' profit maximization problems yield

$$p_A^u = \frac{1 - F_A(\sigma_A^u)}{f_A(\sigma_A^u)} \qquad p_B^u = \frac{1 - x_0 + x_0 F_A(\sigma_A^u)}{x_0 f_A(\sigma_A^u)}, \tag{10}$$

where superscript u distinguishes optimal prices and marginal switching costs with UP.

With uniform prices, firm A's marginal customer has switching cost

$$\sigma_A^u = p_A^u - p_B^u = \frac{2x_0 (1 - F_A(\sigma_A^u)) - 1}{x_0 f_A(\sigma_A^u)} = \frac{1 - 2F_A(\sigma_A^u)}{f_A(\sigma_A^u)} - \frac{1 - x_0}{x_0 f_A(\sigma_A^u)}. \tag{11}$$

Comparing (11) with (7) shows that $\sigma_A^u < \sigma_A^D$ for $x_0 > \frac{1}{2}$.[38]

Expression (11) also shows that σ_A^u and hence the optimal uniform prices depend on x_0. First, (11) shows that σ_A^u increases with x_0. Second, if F_A has a relatively high probability mass on low values of s_A, then σ_A^u tends to be small – and even more when x_0 is closer to $\frac{1}{2}$. This, in turn, means that firm B's price is not much lower than firm A's price - regardless of how skewed the distribution of switching costs of firm B's customers is towards high or low values.[39] While the situation of F_A (and / or F_B) having high probability mass on sets of low values of switching costs may appear inconsistent with the notion of a mature market, such situations may arise as a consequence of a regulatory intervention that is aimed at reducing the switching costs of larger portions of consumers.[40]

[38] Expression (11) also shows that $x_0 > \frac{1}{2}$ is necessary and sufficient for an equilibrium with $p_A^u > p_B^u$ to exist.

[39] This is not an issue in models such as Chen (1997) that assume homogeneous switching costs.

[40] For example, this may be thanks to interventions such as Open Banking in the UK which is meant to

The first-order conditions above have an interesting interpretation:[41] Firm A's reaction function is the same as in the case of HBPD as it relates to its customer base. For the challenger firm B, however, its reaction function is

$$\frac{\partial[p_B F_A(p_A - p_B)]}{\partial p_B} = -\frac{1-x_0}{x_0}. \tag{12}$$

Its reaction function that relates to the dominant firm's customer base shifts outward, relative to the case of HBPD. Hence, the challenger firm competes less vigorously with uniform prices than under HBPD. And this softening of competition is stronger if the challenger's market share $1 - x_0$ is larger.[42] This result is formally given by the following proposition:

Proposition 5.2. *Under Assumptions 1 and 2, with uniform pricing, as compared to HBPD, competition for the dominant firm's customer base softens: Firm A retains a higher fraction of its customer base as its back-book and charges a price that exceeds the prices that it charges to back-book (and hence also) customers under HBPD. The challenger's customers also pay a higher price. Formally,* $\sigma_A^u \leq \sigma_A^D$, $p_A^u \geq p_A^D$, *and* $p_B^u \geq p_B^D - m_B^D$.

Together with the result of Proposition 5.1 this results implies that $p_A^u \geq p_A^D \geq p_A^D - m_A^D$. Thus, the result shows that in our setting with heterogeneous switching costs, where both firms hold the different views about the two markets – each firm considers its own customer base as its strong market – and hence there is "best-response asymmetry", price discrimination need not necessarily intensify competition for all consumers: While all of A's customers and B's "front-book" customers benefit from price discrimination, B's "back-book" customers may or may not benefit from price discrimination, compared to uniform pricing: B's uniform price is set to compete on As turf (see discussion preceding Proposition 5.2), while Bs back-book price is set with respect to Bs turf (see discussion preceding Lemma 5.1).

Therefore, whether the former exceeds the latter depends on three things: First, the incumbents market share x_0 : The higher is the incumbents market share, the more B competes and the lower is Bs uniform price. Second, the switching cost distribution of the incumbents customer base: The more weight that this distribution places on high switching cost – the more As customers are inert – the more B needs to compete to make them switch, and therefore the lower is Bs uniform price. And third, the switching cost distribution of

reduce the inconvenience of disengaged consumers when they shop around.

[41] We are indebted to John Vickers for pointing this out.

[42] B's reaction function satisfies $\frac{\partial}{\partial p_B} p_B F_A(p_a - p_B) = -\frac{1-x_0}{x_0}$. B's profit earned on customers switching away from A is concave: $\frac{\partial^2}{\partial p_B^2} p_B F_A(p_A - p_B) = -2f_A(p_A - p_B) + p_B f_A'(p_- p_B) = -2f_A(p_A - p_B) + \frac{F_A(p_A - p_B) f'(p_A - p_B)}{f_A(p_A - p_B)} < 0$ because F_A is log-concave.

the challengers customer base: The more inert are Bs customers, the more that they can be taken advantage of under HBPD: the higher is Bs back-book price.[43]

Since $\sigma_A^u < \sigma_A^D$, Bs poaching price under HBPD is lower than Bs uniform price. Both are set with respect to As turf. As poaching price, in turn, is set with respect to Bs turf. Therefore, whether Bs uniform price exceeds As poaching price depends on the same three things: First, the incumbents market share x_0 : The higher is the incumbents market share, the more B competes and the lower is Bs uniform price; this is the same as above. Second, the switching cost distribution of the incumbents customer base: The more weight that this distribution places on high switching cost – the more As customers are inert – the more B needs to compete to make them switch, and therefore the lower is Bs uniform price; this also is the same as above. And third, the switching cost distribution of the challengers customer base: The more inert are Bs customers, the more A needs to compete to make them switch, and therefore the lower is As poaching price.

Proposition 5.2 reinforces the observation that – with uniform prices – competition focuses on the dominant firm's customer base only, and the challenger competes less vigorously. This result differs from the unambiguous predictions in models of heterogeneous brand preference and "best-response asymmetry"; e.g. Bester and Petrakis (1996) and Corts (1998). The result is of policy relevance as it is often argued that non-discriminatory interventions are aimed at protecting unengaged customers from being taken advantage of. Our result shows that there exist circumstances in which such interventions would harm some, if not all, locked-in customers.

Note that our argument implies that, while $\sigma_A^u \leq \sigma_A^D$, for x_0 high enough $\sigma_A^u \geq \sigma_A^D - \sigma_B^D$. So for high initial market share x_0, firm A loses more market share under uniform prices than under HBPD. Therefore, this type of intervention would give rise to a trade-off between the competition policy objective of encouraging the challenger firm and the consumer protection objective of protecting "back-book" consumers – but in the opposite direction to what is intended, as under uniform pricing consumers are worse off while the challenger can expand more.[44] This result contrasts with Result 2 in Gehrig et al. (2011) that shows that the market

[43] Beckert et al. (2020) provide empirical evidence that, in a spatially-differentiated product market, price discrimination – compared to UP – benefits most, but not all customers. In that application, switching costs relate primarily to transport.

[44] The encouragement of entry is a competition policy objective in many industrial countries (Khemani and Barsony, 1999). The OECD (2021) considers "the entry of new businesses [...] key to dynamic and resilient economies." The Financial Conduct Authority (2017) stresses that "Challenger firms are an important source of competitive pressure for established businesses, as well as bringing new ideas and innovation. In markets where challengers cannot enter or grow, established firms tend to be less responsive to customers, less efficient and less innovative. Hence, for such markets that provide essential services, competitive pressure is seen as an important lever to ensure their robustness and resilience, responsiveness to consumers, efficiency and innovative capacity.

share of the dominant firm is larger under uniform pricing than under HBPD, because under the linear structure of their Hotelling framework the dominant firm finds it very costly to poach distant customers of the rival firm, which thereby insulates the smaller firm from poaching by its dominant rival.

Since uniform pricing is less competitive than HBPD – as is seen from (12) – it is more profitable for both firms. However, the uniform pricing outcome suffers (in the absence of a regulatory requirement that forces price uniformity) from the problem that it is not sustainable as an equilibrium unless both firms can commit to charging a single price, because price discrimination is always a dominant strategy (Thisse and Vives (1988)). In the model, as in many real-world situations, firms lack that commitment. We will see below how (ratio-based) constraints on the extent of price discrimination can act as a commitment device that allows firms credibly to approximate the uniform pricing outcome.

5.3 Price Discrimination with Leakage

From a consumer protection policy perspective, the traditional view is that consumer disengagement is best addressed by improving transparency. For example, authorities can impose disclosure remedies such as requiring firms to send reminders to their customers when a promotional period is about to expire, perhaps detailing how much the customer could gain by upgrading to another promotional deal offered by the same provider that is typically targeted at new customers.[45] Nevertheless, firms can still rely on HBPD to the extent that existing inert customers might struggle to take corrective action in response to prompts and alerts by the current firm or from third-party intermediaries. We label this configuration HBPD with "leakage", as this intervention effectively imposes a profit sacrifice, due to the risk of revenue cannibalisation as a result of "internal" switching, when poaching rivals' customers.

We model HBPD with leakage as follows: A firm offers its inducement m_j^L, $j = A, B$, which is aimed at its rival's customers as in subsection 5.1, to its own customers as well. Suppose internal switching to the sweetened tariff is only a fraction $\alpha \in (0, 1)$ as expensive as is external switching. If both firms offer a poaching price, below their respective regular price, some customers of both firms switch internally to the sweetened tariff (internal switcher),

[45] Financial Conduct Authority (2015). See Competition and Markets Authority (2016b) for a more sophisticated version of this type of remedy, labelled Open Banking, whereby the largest incumbent banks are required to adopt a standardised application programme interface (API) through which smaller banks and third party intermediaries such as price comparison websites will be allowed to access, with the customer's consent, data on individual consumption profiles and applied tariffs in order to be able to show consumers tailored price comparisons. The UK Financial Services Consumer Panel commissioned a study (published in June 2019) into automatic upgrades of bank customers; see `https://www.fs-cp.org.uk/sites/default/files/automatic_upgrades_research_report.pdf`.

and some stay (are locked in) at the regular price. External switching is only in one direction: to the firm with the lower poaching price.[46] The reason is that B's equilibrium poaching price is lower than A's, and therefore B's customers have no incentive to switch to A: They would pay a higher price and in addition incur switching costs.

Let superscript L denote optimal values under HBPD with leakage. And denote the level of switching costs of the marginal internal switcher by $\sigma_j^{L_i}$, and the switching costs of the marginal external switcher by $\sigma_j^{L_e}$, $j = A, B$. Then, prices and discounts satisfy

$$\begin{aligned} p_j^L &= p_j^L - m_j^L + \alpha\sigma_j^{L_i} \\ p_j^L - m_j^L + \alpha\sigma_j^e &= p_k^L - m_k^L + \sigma_j^{L_e}, \quad j,k = A,B; j \neq k. \end{aligned}$$

Therefore,

$$\sigma_j^{L_i} = \frac{m_j^L}{\alpha} \tag{13}$$

$$\sigma_j^{L_e} = \begin{cases} \frac{p_j^L - p_k^L - (m_j^L - m_k^L)}{1-\alpha} & \text{if } p_j^L - p_k^L - (m_j^L - m_k^L) > 0 \\ 0 & \text{otherwise} \end{cases}, \quad j,k = A,B; j \neq k. \tag{14}$$

Lemma 5.2. *Under HBPD with leakage, each firm has back-book customers with high switching costs, some of whom – with relatively low switching costs – in equilibrium switch internally; and front-book customers, with the lowest switching costs, who in equilibrium may, or may not, switch externally. Formally, the switching costs of the internally and externally marginal customers are* $\sigma_j^{L_i} > \sigma_j^{L_e}$, $j = A, B$.

Proposition 5.3. $\sigma_A^{L_e} > 0$ *(and* $\sigma_B^{*e} = 0$*) if, and only if,* $x_0 \geq \frac{1}{2}$*. And*

$$\sigma_A^{L_i} = \frac{m_A^L}{\alpha} = \frac{1 - F_A(\sigma_A^{L_i})}{f_A(\sigma_A^{L_i})} \tag{15}$$

$$\sigma_B^{L_i} = \frac{m_B^L}{\alpha} = \frac{1 - F_B(\sigma_B^{L_i})}{f_B(\sigma_B^{L_i})} \tag{16}$$

$$\frac{p_A^L - m_A^L}{1-\alpha} = \frac{1 - F_A(\sigma_A^{L_e})}{f_A(\sigma_A^{L_e})} \tag{17}$$

$$\frac{p_B^L - m_B^L}{1-\alpha} = \frac{1 - x_0 + x_0 F_A(\sigma_A^{L_e})}{x_0 f_A(\sigma_A^{L_e})}. \tag{18}$$

Corollary 5.3.1. *The dominant firm's front-book is the same under uniform pricing and HBPD with leakage:* $\sigma_A^{L_e} = \sigma_A^u$.

[46] This is shown formally in Lemma 5.2 below.

The corollary to Proposition 5.3 shows that firm A's marginal customer who is indifferent between staying with A and externally switching to firm B is the same as in the case of UP. The intuition for this result is straightforward: According to (13) both firms act as monopolists when partitioning their own customer base into front-book and back-book customers. Given that partition, both firms set uniform prices with respect to their front-book customers. But to set these prices, (9) implies that only x_0 and $F_A(\sigma_A^e)$ matter, so the result $\sigma_A^{L_e}$ is the same as σ_A^u.

This is an important result because it shows that HBPD with leakage in our setup can be thought of as a toughened version of uniform pricing, while not permitting the challenger to make further inroads into the dominant firm's turf. Indeed, (17) and (18), together with 5.3.1, imply that discounted prices are lower than uniform prices,

$$p_A^L - m_A^L \;=\; (1-\alpha)p_A^u \tag{19}$$
$$p_B^L - m_B^L \;=\; (1-\alpha)p_B^u. \tag{20}$$

And discount levels m_A^L and m_B^L are set with respect to the firms' own back-book: their own respective customer bases' switching costs. In fact, with regard to competition for A's customers, the shift in B's reaction function is characterised by

$$\frac{\partial}{\partial p_B}[p_B F_A(p_A - p_B)] = -(1-\alpha)\frac{1-x_0}{x_0} + \alpha F_A(p_A - p_B) > -\frac{1-x_0}{x_0}, \tag{21}$$

and hence, B is seen to compete more vigorously than with uniform prices, yet less vigorously than with discriminatory prices.

Furthermore, prices that are charged to back-book customers are

$$\begin{aligned} p_A^L &= (1-\alpha)\frac{1-F_A(\sigma_A^{L_e})}{f_A(\sigma_A^{L_e})} + \alpha\frac{1-F_A(\sigma_A^{L_i})}{f_A(\sigma_A^{L_i})} = (1-\alpha)p_A^u + \alpha\frac{1-F_A(\sigma_A^{L_i})}{f_A(\sigma_A^{L_i})} \\ p_B^L &= (1-\alpha)p_B^u + \alpha\frac{1-F_B(\sigma_B^{L_i})}{f_B(\sigma_B^{L_i})}, \end{aligned}$$

so that Lemma 5.2, together with Assumption 2, implies that

$$p_A^L \;\leq\; p_A^u,$$

while p_B^L may or may not exceed p_B^u, depending on the distribution F_B relative to F_A. So A's profit margins on front-book and back-book customers are lower with HBPD with leakage than their margins with uniform pricing, as are the margins that B earns on customers poached from A and on its internal switchers. Hence, HBPD with leakage tends to be more competitive than uniform prices.

Also, as $\alpha \downarrow 0$,

$$p_j^L \ \uparrow \ p_j^u \qquad \text{and} \qquad m_j^L \downarrow 0, \ \ j \in \{A, B\} :$$

As the cost of internal switching vanishes, prices under HBPD with leakage tend to the uniform prices. Since the extent to which consumers switch externally is the same ($\sigma_A^{L_e} = \sigma_A^u$), front-book customers of both firms benefit from HBPD with leakage. Locked-in back-book customers of both firms (who do not switch) also benefit. For internal switchers, consumers benefit if their respective cost of switching – $\sigma_A \in (\sigma_A^u, \sigma_A^{L_i})$ and $\sigma_B \in [0, \sigma_B^{L_i})$ – does not outweigh the respective price difference:

$$\begin{aligned} p_A^U - (p_A^L - m_A^L) &= \alpha \frac{1 - F_A(\sigma_A^u)}{f_A(\sigma_A^u)} \\ p_B^u - (p_B^L - m_B^L) &= \alpha \frac{1 - x_0(1 - F_A(\sigma_A^u))}{x_0 f_A(\sigma_A^u)}. \end{aligned}$$

By (15) and (16), the average cost of internal switching does not depend on the cost advantage of internal switching (α), while the price advantage under HBPD with leakage relative to uniform pricing does. Indeed, the smaller is the cost of internal switching, the *less* this is reflected in a price gain: the less that HBPD with leakage benefits those customers whose switching the switching requirement is designed to facilitate.

Finally, when we compare (7) with (15), and (8) with (16), it follows that

$$\begin{aligned} \sigma_A^{L_i} &> \sigma_A^D > \sigma_A^{L_e} = \sigma_A^u \\ \sigma_B^{L_i} &> \sigma_B^D > 0. \end{aligned}$$

These inequalities imply the following result.

Proposition 5.4. *Under Assumptions 1 and 2, the prices that are charged to back-book and customers are higher under HBPD with leakage than with HBPD:*

$$\begin{aligned} p_A^L > p_A^D \qquad & p_B^L > p_B^D \\ p_A^L - m_A^L > p_A^D - m_A^D \qquad & p_B^L - m_B^L > p_B^D - m_B^D. \end{aligned}$$

Therefore, HBPD with leakage softens competition relative to history-based price discrimination. Since under HBPD with leakage $\sigma_A^{L_i} > \sigma_A^D$ and $\sigma_B^{L_i} > \sigma_B^D$, customers of both firms are more likely also to bear a switching cost. This reinforces the consumer welfare reducing effect of HBPD with leakage relative to history-based price discrimination.

When the dominant firm is an established incumbent and the challenger is a new entrant that is competing for the market, the challenger has less scope to price discriminate compared to the incumbent, for whom price discrimination is a dominant strategy. In such situations, asymmetric interventions that impose leakage may benefit the entrant:

Proposition 5.5. *An asymmetric regulatory intervention whereby the imposition of a disclosure requirement that yields "leakage" is solely directed at the incumbent increases the entrant's profit, and this increase is larger the less expensive is internal switching: the smaller is* α*.*

When the cost of internal switching is low, then this limits the incumbent's temptation and ability to price discriminate, and this facilitates an outcome that approximates uniform pricing – which is the least competitive and most profitable regime.[47]

5.4 Pegged Prices - Ratio-Based Price Regulation

Another regulatory intervention that has been proposed recently is to constrain the dispersion of discriminatory prices, by pegging the magnitude of discounts to the level of the regular, undiscounted price.[48] We therefore label this pricing regime HBPD with a peg, or ratio-based price discrimination. Under this pricing regime, "front-book" customers would effectively be relied upon to protect "back-book" customers, limiting the extent to which firms can take advantage of the latter and charge them relatively excessive prices.[49] The pegging constraint would make price discrimination against customers with high switching costs more difficult. Arguably, it would also increase clarity and transparency about pricing structures and mitigate concerns about inequitable treatment.

We model the peg as bounding the ratio between the regular and discounted prices: The discount m_i is no more than a fraction $\beta \in (0, 1)$ of the regular price p_i: $m_i \leq \beta p_i$ for $i \in \{A, B\}$.

[47]As we noted in a footnote above, HBPD with leakage can be interpreted as a form of an MFCC. To the best of our knowledge there is no extant economic literature researching the incentive to use MFCCs where customers face heterogeneous 'hassle' costs to claim for compensation, so that it translates into a form of third-degree price discrimination. Besanko and Lyon (1993) analyse firms' incentives to adopt MFCCs where consumers are partitioned between "non shoppers", who never consider switching, and "shoppers", who have no brand preference. However, the MFCC applies to every customer indiscriminately, so the use of an MFCC also amounts to a non-discrimination commitment device. Besanko and Lyon (1993) show that there can be configurations where firms have a unilateral incentive to use contemporaneous MFCCs.

[48](Financial Conduct Authority, 2018a,b).

[49]In this sense, this configuration is reminiscent of the relationship between 'tourists' and 'locals' in the classic model of price dispersion of Varian (1980), with the difference that in that seminal paper firms randomise over a range of (uniform) prices as they face a trade-off between exploiting the former and competing for the latter: see Armstrong (2015) for a discussion.

Adding the ratio constraints $m_A \leq \beta p_A$ and $m_B \leq \beta p_B$ to the firms' profit maximization problems with HBPD, the solutions $p_A^R, p_B^R, m_A^R, m_B^R$ and σ_A^R, σ_B^R now satisfy the following result.

Proposition 5.6. *Under Assumptions 1 and 2, compared to HBPD, ratio-based price discrimination softens competition: The both firms retain fractions of their back-book customer bases, and charge prices, that are no less than under HBPD:*

$$\begin{aligned} \sigma_A^R \leq \sigma_A^D &\qquad \sigma_B^R \leq \sigma_B^D \\ p_A^R \geq p_A^D &\qquad p_B^R \geq p_B^D \\ p_B^R - m_A^R \geq p_A^D - m_A^D &\qquad p_B^R - m_B^R \geq p_B^D - m_B^D. \end{aligned}$$

This proposition encompasses UP and HBPD as special cases. Its proof shows that UP is a special case – for $\beta = 0$ – while HBPD emerges for β that is sufficiently close to one. The ratio constraint acts as a commitment device that limits the extent to which firms can succumb to the prisoners' dilemma to discriminate. Unlike HBPD with leakage however, and like HBPD, ratio-based price discrimination does not protect the challenger's customer base.

In conclusion, when we compare the four regimes that are studied in this paper, UP is the least competitive, with firms just competing for the dominant firm's marginal customer. This is followed by HBPD with leakage where each firm competes with itself to discriminate against its back-book, and where both firms compete for the dominant firm's marginal customer, as in UP; and then by ratio-based price discrimination, where the ratio constraint acts as a commitment device to limit the extent of poaching, but both firms make incursions into each other's customer base. HBPD tends to be the most competitive regime, with firms segmenting consumers into the two markets that constitute each firm's customer base.[50]

6 Extensions

In this section, we provide an informal discussion of some extensions to our model.

6.1 Asymmetric Costs

An often-cited regulatory concern is that a challenger's customer acquisition cost are higher than the dominant firm's customer retention cost. This wedge is a marginal cost supplement

[50] This is with the caveat that, as we showed, there may be circumstances where the challenger's back-book customers may pay a discriminatory price above the uniform price.

for poaching the rival's customers, to the detriment of the challenger. Our model can be adapted to such asymmetric marginal costs, with the challenger's marginal cost exceeding those of the dominant firm: $c_A < c_B$. The cost differential $\Delta = c_A - c_B < 0$ that favours the dominant firm implies that A finds it easier to defend its turf: For HBPD, for example, σ_A^D is lower and σ_B^D is higher than in the case of symmetric marginal cost; similarly, the cost differential reduces σ_A^u in the context of UP .

6.2 Entry Deterrence

In his study of dynamic price discrimination with asymmetric firms and consumers with brand preferences, Chen (2008) concludes that HBPD is beneficial to consumers as long as it is not used as a means by the incumbent dominant firm to deter entry (or induce exit) of the smaller challenger firm.[51] In Appendix B we show that when there are sunk costs that are associated with entry, HBPD on the part of the incumbent dominant firm, as opposed to uniform pricing, erects a higher entry barrier for a (uniform-pricing) challenger. The intuition is that post entry with UP firms only compete for the marginal customers of firm A, while with HBPD firms compete for the marginal customers of both firms. Since the former setting is less competitive than the latter, the challenger is less deterred by a uniformly pricing incumbent than by an incumbent that charges discriminatory prices. In light of ratio-based pricing and HBPD with leakage having some of the attributes of UP and thus being less competitive than HBPD, this suggests that such regulatory constraints could facilitate entry.

6.3 Oligopolistic Markets

Many markets of interest may accommodate more than two firms. There can be several dominant firms, or several challenger firms, or both. If a firm can distinguish only between current customers and non-customers – and not distinguish which rival firm poached its customers – then the duopolistic market structure is a good approximation.

With more firms, competition is more vibrant, and this can be captured by allowing F_A and F_B respectively to have more probability mass on lower switching cost, which leads to lower prices. If there are more dominant firms, competition before the challengers show up is more intense, so challengers have to compete more aggressively to gain market share. If

[51] Entry deterrence in the presence of switching costs absent price discrimination and with complete information has been studied by Klemperer (1987) who considers limit pricing: reductions in a uniform price to deter entry; and by Farrell and Shapiro (1988a) who show that when an incumbent cannot price discriminate switching costs can actually promote entry. See also (Chen, 2008; Fumagalli and Motta, 2013; Gehrig et al., 2012; Karlinger and Motta, 2012).

there are more challenger firms and a monopolist dominant firm, the challengers compete not only with the dominant firm but also with each other because the most efficient challenger will set the competitive benchmark.

6.4 Endogenising the Market Structure

We argued above that, from a competition policy perspective, the asymmetric market structure and heterogeneity of switching cost distributions across firms that were introduced in sections 4.1 and 4.2 that underpin the central analyses of the paper are often of particular interest: A typical initial market configuration involves a dominant firm that faces a challenger, and the challenger – having acquired low-switching-cost consumers – has a customer base that is more prone to switching than is true for the customer base of the dominant firm. There are many conceivable possible avenues to endogenise such asymmetries in a dynamic model.[52] It is not difficult to see that technical obstacles emerge rapidly, and handling these in a general setting such as ours, for each of the pricing regimes, goes beyond the scope of this paper.

We sketch one such avenue: Under some simplifying assumptions, the asymmetric market structure of the previous section can emerge as the second period (in a two-period model) that follows an initial period in which an incumbent homogenous-good monopolist (A) faces a challenger entrant (B). We follow Farrell and Shapiro (1988b) in assuming that, after the first-period, some new customers (with switching cost distribution F) will replace some old customers. Unlike Farrell and Shapiro (1988b), we assume that the new customers *exogenously* replace customers at both firms,[53] so that the support of the switching cost distributions F_A and F_B of th e firms' customer bases post entry is the same, and the two distributions satisfy Assumption 1. We therefore take the second period switching cost distributions F_A and F_B as exogenous.[54]

7 Conclusions

This paper studies options for price regulation to protect sticky consumers in asymmetric oligopolistic markets where firms' customers have heterogeneous switching costs. We evaluate these options against criteria such as the extent of discrimination, of consumer switching and thereby of market penetration by a challenger, and of unintended consequences such as a

[52]For example, Caillaud and De Nijs (2014) and Esteves (2014) study behaviour-based price discrimination in a dynamic setting.

[53]Farrell and Shapiro (1988b) assume that the new customers join the firm with the lower price.

[54]The detailed dynamic analysis is available from the authors upon request.

general rise in the prices of the oligopolists .

We show that in a setting with asymmetric market shares and heterogeneous switching costs, HBPD with leakage and ratio-based price discrimination are more competitive than is UP, but less competitive than HBPD. Therefore disclosure remedies - in the form of price discrimination with leakage - and remedies to limit price dispersion - in the form of price pegs - dissipate much of the benefits of price discrimination.

We also show that the pricing regime affects the extent to which the challenger makes inroads into the dominant firm's turf. Such penetration is the same whether prices are uniform or discriminatory but subject to disclosure, and but less than when prices are discriminatory without constraints, although in that case there is also reverse penetration by the incumbent. Subject to additional pegging constraints, bidirectional penetration occurs but is more muted than with HBPD. Furthermore, we show that HBPD by an incumbent can deter a challenger's entry altogether, while HBPD with leakage and ratio-based PD may facilitate entry.

These findings, in turn, imply that in settings such as ours consumer protection objectives may well be in conflict with competition objectives. In markets that provide essential services, the competition policy objective of facilitating entry is of paramount importance to sustain competitive pressure and, as a result, ensure their operational resilience and robustness, responsiveness to consumers, efficiency and innovative capacity.[55] The objective of low prices – which is best supported by the more intense competition that is afforded by HBPD – may soften competition for the market, deter entry and induce the greatest extent and cost of consumer switching. HBPD with leakage and ratio-based price discrimination may therefore strike a balance as they moderate price levels and the extent of switching, and they do not erect prohibitive barriers to entry. When internal switching is not too costly, disclosure remedies may be preferable if entry is to be encouraged and the challenger is to be protected from its turf being penetrated in reverse by the incumbent.

Our results are relevant in many dynamic, newly emerging retail and business-to-business markets where disruptive entrants exist or are encouraged, market shares are asymmetric, customers are price-takers and exhibit heterogeneous switching costs. These characteristics are salient in many markets that have come or currently are under regulatory scrutiny.

Our findings challenge policy makers to balance concerns about equitable and "fair" treatment of buyers and consumers with competition objectives that aim at reducing barriers to entry. And thus they are relevant for competition bodies, such as the U.S. Federal Trade Commission, the U.S. Department of Justice and the CMA, when calibrating their

[55]See, e.g., Financial Conduct Authority (2017) and OECD (2021).

objectives.[56]

The erosion of trust in institutions – including markets – has emerged as a theme of increasing political salience. Market regulators therefore feel a duty to stem this erosion of trust and restore the confidence that markets can benefit everyone. It is therefore important for them to anticipate the potential distributional implications of regulatory interventions, and to weigh the trade-offs among their interventions and other policy objectives.

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[56]The CMA's recent annual plans re-calibrate its objectives, stressing that the competition and consumer protection regimes need to work in tandem alongside each other, to ensure that vulnerable consumers are not exploited and that markets work in their favour. The protection of vulnerable consumers has thus become an objective of particular strategic importance. See, for example, the CMA's Annual Plans 2018-19 and 2019/20 that define helping vulnerable people as one of the CMA's strategic priorities. Some of the FTC's work has specifically focussed on the elderly; see, for example, Federal Trade Commission (2018).

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A Proofs

Proof of Lemma 5.1: The result follows immediately from equations (7) and (8) and assumptions 1 and 2.

An alternative argument proceeds as follows. Assumption 1 implies H and RH. Suppose that the opposite were true: $\sigma_A < \sigma_B$. Then, by RH and Assumption 2, for $\sigma_A^D < s < \sigma_B^D$,

$$\frac{F_A(\sigma_A^D)}{f_A(\sigma_A^D)} \leq \frac{F_A(s)}{f_A(s)} \leq \frac{F_B(s)}{f_B(s)} \leq \frac{F_B(\sigma_B^D)}{f_B(\sigma_B^D)},$$

and so the last two first-order conditions imply $p_B^D - m_B^D \leq p_A^D - m_A^D$. H and Assumption 2 imply,

$$\frac{1 - F_B(\sigma_B^D)}{f_B(\sigma_B^D)} \leq \frac{1 - F_B(s)}{f_B(s)} \leq \frac{1 - F_A(s)}{f_A(s)} \leq \frac{1 - F_A(\sigma_A^D)}{f_A(\sigma_A^D)},$$

and the first two first-order conditions in turn imply $p_B^D \leq p_A^D$. Therefore, the two inequalities imply $\sigma_B^D = p_B^D - p_A^D + m_A^D \leq p_A^D - p_B^D + m_B^D = \sigma_A^D$, which is a contradiction. □

Proof of Proposition 5.1: From $\sigma_A^D \geq \sigma_B^D$ and the first-order conditions, it follows that $2(p_A^D - p_B^D) \geq m_A^D - m_B^D$. So it is sufficient to prove that $m_A^D \geq m_B^D$.

From the definitions of σ_A and σ_B,

$$\sigma_A^D + \sigma_B^D = m_A^D + m_B^D,$$

and from the first-order conditions,

$$\begin{aligned} \sigma_A^D &= p_A^D - p_B^D + m_B^D = m_A^D + \frac{F_B(\sigma_B^D)}{f_B(\sigma_B^D)} - \frac{F_A(\sigma_A^D)}{f_A(\sigma_A^D)} \\ \sigma_B^D &= p_B^D - p_A^D + m_A^D = m_B^D + \frac{F_A(\sigma_A^D)}{f_A(\sigma_A^D)} - \frac{F_B(\sigma_B^D)}{f_B(\sigma_B^D)}. \end{aligned}$$

Lemma 5.1, together with Assumption 2, implies that $\frac{F_B(\sigma_B^D)}{f_B(\sigma_B^D)} - \frac{F_A(\sigma_A^D)}{f_A(\sigma_A^D)} \leq 0$. Therefore, $0 \leq m_A^D - \sigma_A^D = \sigma_B^D - m_B^D$, and hence

$$m_B^D \leq \sigma_B^D \leq \sigma_A^D \leq m_A^D.$$

□

Proof of Proposition 5.2: It is sufficient to prove that $\sigma_A^u \leq \sigma_A^D$, which implies, by the first-order conditions for firm A and Assumption 2, that $p_A^u \geq p_A^D$. This, together with $\sigma_A^D > \sigma_B^D > 0$ under HBPD, as shown in Lemma 5.1, by Assumption 2 implies also $p_B^u \geq p_B^D - m_B^D$.[57]

Suppose to the contrary that $\sigma_A^u > \sigma_A^D$. Then, $p_A^u \leq p_A^D$ by the first-order conditions and Assumption 2. This ranking of prices of firm A, together with the supposition, implies also that $p_B^u \leq p_B^D - m_B^D$.[58] Therefore, $p_B^u - c \leq p_B^D - c - m_B^D$, and hence

$$\frac{1 - x_0 + x_0 F_A(\sigma_A^u)}{x_0 f_A(\sigma_A^u)} \leq \frac{F_A(\sigma_A^D)}{f_A(\sigma_A^D)}.$$

Notice that $x_0 = 1$ implies $\sigma_A^u = \sigma_A^D$. Since the lefthand side of the inequality is decreasing in x_0, Assumption 2 implies that $\sigma_A^u < \sigma_A^D$ for $\frac{1}{2} < x_0 < 1$, which is a contradiction to the supposition. □

Proof of Lemma 5.2: Suppose, to the contrary, that $\sigma_j^i < \sigma_j^e$. Then, a customer of firm j with s such that $\sigma_j^i < s < \sigma_j^e$, switches externally, but not internally, iff

$$p_k^L - m_k^L + s < pj^L - m_j^L + \alpha s,$$

or iff

$$(1-\alpha)s < p_j^L - p_k^L - (m_j^L - m_k^L).$$

A customer of firm j with $s' < \sigma_j^i$ switches internally, but not externally, iff

$$p_k^L - m_k^L + s' > pj^L - m_j^L + \alpha s',$$

or iff

$$(1-\alpha)s' > p_j^L - p_k^L - (m_j^L - m_k^L).$$

But then, $s' > s$, which is a contradiction. □

Proof of Proposition 5.3: Suppose external switching is from A to B and $\sigma_A^e > 0$. Then,

$$\begin{aligned} \pi_A^L &= x_0 p_A^L (1 - F_A(\sigma_A^e)) - m_A^L x_0 \left(F_A(\sigma_A^i) - F_A(\sigma_A^e)\right) \\ \pi_B^L &= (1-x_0)p_B^L - m_B^L(1-x_0)F_B\left(\sigma_B^i\right) + x_0(p_B^L - m_B^L)F_A\left(\sigma_A^e\right). \end{aligned}$$

[57] The situation of uniform prices is akin to $\sigma_B^D = 0$: None of firm B's customers switch. Assumption 2 then implies that p_B^D for $\sigma_B^D > 0$ is lower than the corresponding price if σ_B were zero.

[58] This is because, under the supposition, $p_A^D - p_A^u > p_A^u - p_B^u = \sigma_A^u > \sigma_A^D = p_A^D - p_B^D + m_B^D$.

The first-order conditions for the firms' profit maximization problem yield

$$\begin{aligned}
\sigma_A^{*i} &= \frac{m_A^{*L}}{\alpha} = \frac{1-F_A(\sigma_A^{*i})}{f_A(\sigma_A^{*i})} \\
\sigma_B^{*i} &= \frac{m_B^{*L}}{\alpha} = \frac{1-F_B(\sigma_B^{*i})}{f_B(\sigma_B^{*i})} \\
\frac{p_A^{*L}-m_A^{*L}}{1-\alpha} &= \frac{1-F_A(\sigma_A^{*e})}{f_A(\sigma_A^{*e})} \\
\frac{p_B^{*L}-m_B^{*L}}{1-\alpha} &= \frac{1-x_0+x_0F_A(\sigma_A^{*e})}{x_0 f_A(\sigma_A^{*e})}.
\end{aligned}$$

Therefore,

$$\begin{aligned}
\sigma_A^{*e} &= \frac{p_A^{*L}-m_A^{*L}}{1-\alpha} - \frac{p_B^{*L}-m_B^{*L}}{1-\alpha} \\
&= \frac{2x_0\left(1-F_A(\sigma_A^{*e})\right)-1}{x_0 f_a(\sigma_A^{*e})},
\end{aligned}$$

which shows that $\sigma_A^e > 0$ if, and only if, $x_0 \geq \frac{1}{2}$. □

Proof of Proposition 5.4: Since $\sigma_B^{L_e} = 0$, $\sigma_B^D > 0$ implies that $p_A^D - m_A^D < p_A^L - m_A^L$; $\sigma_A^D > \sigma_A^{L_e}$ implies $p_B^D - m_B^D < p_B^L - m_B^L$; and $\sigma_j^{L_i} > \sigma_j^D$ implies $p_j^L > p_j^D$, $j \in \{A, B\}$. □

Proof of Proposition 5.5: This result is another corollary to Proposition 5.3. The Corollary 5.3.1 shows that $\sigma_A^e = \sigma_A^u$ does not depend on α. So the challenger's profit depends only on p_B^L - with $m_B^L = 0$ -, and (18) shows that this price is increasing in α. If "leakage" is only imposed on A, then the challenger competes as in the case of UP – less vigorously – and its reaction function shifts according to (12), rather than (21). At the same time, A also competes with itself, and this is greater when the cost of internal switching is lower. Hence A's means to discriminate are reduced relative to conventional HBPD, and that benefits the challenger. In the limit, as α tends to zero, this yields the UP outcome which is the most profitable for both firms. □

Proof of Proposition 5.6: The firms' profit maximization problem, subject to the ratio constraints – $m_A - \beta p_A \leq 0, m_B - \beta p_B \leq 0$ – is to maximise

$$\begin{aligned}
\pi_A &= p_A x_0(1-F_A(\sigma_A)) + (p_A - m_A)(1-x_0)F_B(\sigma_B) + \lambda_A(m_a - \beta p_A) \\
\pi_B &= p_B(1-x_0)(1-F_B(\sigma_B)) + (p_B - m_B)x_0 F_A(\sigma_A) + \lambda_B(m_B - \beta p_B),
\end{aligned}$$

and the first-order conditions yield

$$
\begin{aligned}
p_A^R &= \frac{1-F_A(\sigma_A^R)}{f_A(\sigma_A^R)} + \lambda_A^R \frac{\beta-1}{x_0 f_A(\sigma_A^R)} \\
p_B^R &= \frac{1-F_B(\sigma_B^R)}{f_B(\sigma_B^R)} + \lambda_B^R \frac{\beta-1}{(1-x_0) f_B(\sigma_B^R)} \\
p_A^R - m_A^R &= \frac{F_B(\sigma_B^R)}{f_B(\sigma_B^R)} + \lambda_A^R \frac{1}{(1-x_0) f_B(\sigma_B^R)} \\
p_B^R - m_B^R &= \frac{F_A(\sigma_A^R)}{f_A(\sigma_A^R)} + \lambda_B^R \frac{1}{x_0 f_A(\sigma_A^R)},
\end{aligned}
$$

where σ_j^R are defined analogously to σ_j^D and the Kuhn-Tucker Theorem yields $\lambda_j^R \geq 0$, $j \in \{A, B\}$. Also,

$$
\sigma_A^R = \frac{1-2F_A(\sigma_A^R)}{f_A(\sigma_A^R)} + \frac{1}{x_0 f_A(\sigma_A^R)}(\lambda_A^R(\beta-1) - \lambda_B^R) \quad (22)
$$

$$
\sigma_B^R = \frac{1-2F_B(\sigma_B^R)}{f_B(\sigma_B^R)} + \frac{1}{(1-x_0) f_B(\sigma_B^R)}(\lambda_B^R(\beta-1) - \lambda_A^R). \quad (23)
$$

Since $\lambda_A^R(\beta-1) - \lambda_B^R$ and $\lambda_B^R(\beta-1) - \lambda_A^R$ are non-positive, Assumption 2 implies that $\sigma_j^R \leq \sigma_j^D$ and so $p_j^R \geq p_j^D$, $j \in \{A, B\}$. When β is large enough so that the ratio constraints do not bind, $\lambda_A^R = \lambda_B^R = 0$ and (22) and (23) imply the HBPD result. When $\beta = 0$, then, from Proposition (5.2) $\sigma_B^R = 0$ and so (23) implies $\lambda_A^R + \lambda_B^R = 1 - x_0$, so that (22) implies that $\sigma_A^R = \sigma_A^u$. □

B Price Discrimination as Entry Deterrence

In order to investigate the incumbent's HBPD as an entry deterrence strategy in our setting, suppose that the market is dynamic, in the sense that over time some customers leave the market while others join the market. Specifically, for a market size τ, suppose that the fraction of 'new' customers that the challenger can capture – $(1-x_0)\tau$ – to 'old' customers that are served by the incumbent – $x_0\tau$ – is a constant $\kappa = \frac{1-x_0}{x_0}$; and suppose that τ itself is ex ante uncertain. Then the challenger's profits - when pricing uniformly and facing a price discriminating incumbent and conditional on x_0 - are

$$
\pi_B^*(\tau) = \tau \frac{\left(\kappa\left(1-F_B(\sigma_B^*)\right) + F_A(\sigma_A^*)\right)^2}{\kappa f_B(\sigma_B^*) + f_A(\sigma_A^*)}.
$$

Notice that

$$
\begin{aligned}
\sigma_A^* &= p_A^* - p_B^* = \frac{1 - F_A(\sigma_A^*)}{f_A(\sigma_A^*)} - \frac{\kappa\,(1 - F_B(\sigma_B^*)) + F_A(\sigma_A^*)}{\kappa f_B(\sigma_B^*) + f_A(\sigma^* A)} \\
\sigma_B^* &= p_B^* - p_A^* + m_A^* = \frac{\kappa\,(1 - F_B(\sigma_B^*)) + F_A(\sigma_A^*)}{\kappa f_B(\sigma_B^*) + f_A(\sigma^* A)} - \frac{F_B(\sigma_b^*)}{f_B(\sigma_B^*)} :
\end{aligned}
$$

The switching costs of the marginal customer depend on κ, but not on τ.

Then, if the challenger firm has not entered the market yet, its expected profit from entering is given by

$$
\mathbb{E}\left[\pi_B^*(\tau)\right] = \mathbb{E}\left[\tau\right] \frac{\left(\kappa\,(1 - F_B(\sigma_B^*)) + F_A(\sigma_A^*)\right)^2}{\kappa f_B(\sigma_B^*) + f_A(\sigma_A^*)}.
$$

When the incumbent prices uniformly,

$$
\mathbb{E}[\pi_B^{*u}(\tau)] = \mathbb{E}\left[\tau\right] \frac{\left(\kappa + F_A(\sigma_A^{*u})\right)^2}{f_A(\sigma_A^{*u})},
$$

and this is seen to exceed $\mathbb{E}[\pi_B^*(x_0)]$.[59] So, as the challenger compares expected profit from entry with any sunk cost that is associated with entry, price discrimination on the part of the incumbent, as opposed to uniform pricing, erects a higher entry barrier for a uniform-pricing challenger.

[59]The numerator of the fraction inside the expectation is larger for every x_0 because $\sigma_A^{*u} \geq \sigma_A^*$, and the denominator is smaller.