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# Protecting vulnerable consumers in "switching markets"

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# Protecting Vulnerable Consumers in "Switching Markets"*

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**Abstract**

This paper studies regulatory policy interventions aimed at protecting vulnerable consumers who are disengaged and thus exposed to exploitation. 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, both with regard to the stated consumer protection objective and the complementary aim to promote competition.

JEL classification: L11, L13, D4

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## 1 Introduction

The presence of sticky, or "unengaged", consumers who find it costly to switch from their current service provider is arguably one of the most intractable issues faced by competition and consumer protection authorities [Authority for Consumers and Markets, 2014, Canadian Radio-television and Telecommunications Commission, 2017, European Commission, 2016, Financial Conduct Authority, 2015, Hortaçsu et al., 2017, OECD, 2017]. From a competition policy perspective, such loyal customers, often labelled a provider's "back-book", are said

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to convey unfair competitive advantages to large oligopolistic incumbents because they are typically more profitable than "front-book" customers who are more active, regularly shop around in search for a better deal and find it less costly to switch [Productivity Commission, 2018].

The kind of markets that form the backdrop to our analysis involve utilities such as retail energy, basic telecom services and retail financial services such as current accounts. They provide essential services that every consumer must purchase to satisfy basic needs. Hence, consumers typically show very 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; i.e. the main trigger for shopping around is having suffered a severe service disruption. Therefore, given that these markets typically exhibit full market coverage, the potential lock-in of consumers who find it costly to switch and their exploitation are significant policy concerns.

These markets are nevertheless dynamic and have recently experienced entry by "challenger" firms. Yet "challenger" firms typically face barriers to entry and expansion due to higher customer acquisition costs, i.e. to overcome consumer inertia, and they risk that the make-up of their customer base ends up being overexposed towards customers with low switching costs and hence high propensity to switch [Authority for Consumers and Markets, 2014, Financial Conduct Authority, 2015]. This typically gives rise to asymmetric market shares, at least initially.

In this paper, we study an array regulatory policy interventions aimed at protecting consumers whose switching costs make them disengaged and vulnerable to exploitation. In a duopoly setting, we model heterogeneous switching costs of consumers alongside asymmetric market shares. We thereby investigate how the distribution of switching costs and market shares interact under various pricing regimes that arise from regulatory intervention. We evaluate the regimes in terms of welfare of vulnerable consumers and discuss their implications for competition.

Pricing regimes indeed may impact on market structure. Compounding the issue of consumer inertia creating entry and expansion barriers, incumbents can recur to the use of behavioural-based price discrimination (BBPD) in order to stifle the growth of "challenger" firms or deter entry altogether. One obvious form of BBPD is history-base price discrimination (HBPD), whereby firms offer separate poaching prices to rivals' customers, typically at a discount off the price paid by existing customers, and possibly to the detriment of the retained customers [Financial Conduct Authority, 2017]. [1] The combined effect of the initial

[1] For example, [Competition and Markets Authority, 2016a], para 8.232ff, finds evidence of price discrimination between new start-ups and established businesses with respect to business current accounts.

asymmetry of market shares and the potential exploitation of a large portion of locked-in consumers suggests potentially very large consumer detriment [Competition and Markets Authority, 2016a,b, Hortaçsu et al., 2017]. Furthermore, the study of history-based price discrimination with asymmetric market shares is policy relevant because, at least in Europe, the abuse of market dominance is only an issue, in light of Article 102 of the Treaty on the Functioning of the European Union, if the firm in question holds a dominant position.

From a consumer protection policy perspective, the traditional view is that consumer disengagement is best addressed by improving transparency, to spur disengaged consumer to start shopping around by helping them appreciate that there are material gains from switching. 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 they could gain by switching to another promotional deal that is typically targeted at new customers [Financial Conduct Authority, 2015].[2] This type of disclosure remedy effectively rules out the use of HBPD [Financial Conduct Authority, 2016, OECD, 2016].[3] Nevertheless, firms can still rely on BBPD, to the extent that existing customers with relatively high switching costs might still struggle to take corrective action in response to prompts and alerts received by the current firm or shopping advice obtained from third-party intermediaries.[4] We label this configuration HBPD with "leakage", in the sense that this type of intervention effectively imposes a profit sacrifice, due to the risk of revenue cannibalisation as a result of "internal" switching, when poaching rivals' customers.

Support for the traditional reliance on disclosure remedies is waning, however. This is on the basis of evidence that the use of prompts and alerts is ineffective towards a core of "back-book" customers with high switching costs [Adams et al., 2018, Financial Conduct Authority, 2018a][5]. The persistent exploitation of "back-book" customers is seen

[2]See [Competition and Markets Authority, 2016a] 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 customers consent, data on individual consumption profiles and applied tariffs in order to be able to show consumers tailored price comparisons.

[3]See, for example, the literature published by Nationwide, the largest UK building society, with respect to its range of savings products which includes a commitment to offer "brand new customer only" savings accounts, available at https://www.nationwide.co.uk/support/support-articles/terms-and-conditions/savings-accounts. Effectively, this type of disclosure remedy compels firms to try to retain customers by making available to them the same deals offered to new customers.

[4]In this sense, it could be argued that this configuration effectively resembles the use of most-favoured-customer clauses (MFCCs) when consumers face heterogeneous "hassle" cost to enforce their right by asking their current service provider to match the lower price offered to other (potentially new) customers.

[5]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 (ie, 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

as particularly problematic to the extent that those consumers with high switching costs are typically considered to be vulnerable due to certain demographic attributes such as low income, low scholarly achievements and old age [Competition and Markets Authority, 2016b, Financial Conduct Authority, 2018b]. Accordingly, there are calls for stronger remedial interventions aimed at directly restricting firms' ability to exploit "back-book" customers on fairness grounds.[6]

A straightforward option would be to ban price discrimination altogether, so that firms are only allowed to set one price for both, "back-book" and "front-book" customers, be they existing and prospective ones.[7] Such a draconian intervention, though, is normally considered to be a sort of backstop remedy of last resort[Financial Conduct Authority, 2018a,b]. This remedy would effectively implement a uniform pricing (UP) regime.

An alternative, subtler option would be to permit HBPD but requiring that the "lock-in" price charged to "back-book" customers is pegged to the "poaching" price offered to new customers, e.g. by setting a maximum multiple for the ratio of the former price to the latter one [Financial Conduct Authority, 2018a,b]. Under this pricing regime, "front-book" customers would effectively be relied upon to protect 'back-book" ones from unfair exploitation due to excessive prices.[8] We label this pricing regime HBPD with a peg.

In general, though, regulatory intervention aimed at protecting "back-book" customers is fraught with concerns about equity and about its impact on the intensity of competition.[9] Therefore, it is very important to understand under what circumstances policy interventions aimed at protecting unengaged customers from exploitation would actually work. We characterise the conditions under which "locked-in" prices charged to "back-book" customers under

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]

[6]See Competition and Markets Authority [2016b], 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 UK Government,"Victory for consumers as cap on energy tariffs to become law - New bill will protect millions more households from unfair price rises", Press release, 19 July 2018, available at `https://www.gov.uk/government/news`.

[7]A similar outcome would result from a requirement that firms automatically upgrade consumers to their cheapest available tariff.

[8]In this sense, this configuration is reminiscent of the relationship between tourist' 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.

[9]For example, OECD [2016], para. 136, report that the UK energy regulator imposed a non-discrimination requirement on energy firms. However, after receiving criticism the CMA identified this as softening competition and has therefore recommended its removal.

HBPD are lower than those they would face under uniform pricing, HBPD with "leakage" and HBPD with a "peg".

Besides the distributional impact to the detriment of "front-book" consumers, consumer protection policy interventions that are ultimately aimed at unwinding the use of HBPD are also contentious from a competition policy perspective. On the one hand, it is well-established that the use of price discrimination under oligopoly can intensify pricing rivalry where competing firms exhibit best-response asymmetry, in that they hold opposing view as to which consumers are "strong" and which are instead "weak" [Armstrong, 2006b]. On the other hand, the use of HBPD by the dominant incumbent may be part of an exclusionary anticompetitive strategy aimed at foreclosing a potential entrant whilst mitigating the entailed profit sacrifice [Fumagalli and Motta, 2013, Gehrig et al., 2012, Karlinger and Motta, 2012]. We investigate this potential trade-off by comparing firms profits and market shares under the various pricing regimes investigated.

Ultimately, our aim is to investigate under what circumstances there may also be a trade-off between the consumer protection policy objective to protect "back-book" consumers and the competition policy objective to sponsor "challenger" rival firms. With respect to the latter, we also model asymmetric treatments where only one firm, typically the larger incumbent, is subjected to the regulatory requirement.

This paper studies pricing models – unrestricted HBPD, HBPD subject to disclosure (internal "leakage") and pegging restrictions, and UP - with random heterogeneous switching costs that differ across duopolistic firms with asymmetric market shares. In doing so, the paper generalizes and extends the analysis of "mature markets" with common uniformly distributed switching costs in Chen [1997]. Our framework is related to Gehrig et al. [2012] who study the welfare implications of HBPD under asymmetric market shares. The authors find that even when firms can price discriminate between new and current customers, poaching might not take place if switching costs are sufficiently high. Moreover, where market shares are particularly skewed, the erosion of the larger firm's customer base is larger than under uniform pricing. Indeed, for very asymmetric inherited market shares the larger firm may not offer a poaching offer given that it would be too costly to attract marginal customers that are close to the previous cut-off point, but very far from the opposite extreme where the dominant firm is located. This is because, similar to Thisse and Vives [1988], the authors also include brand preferences under a linear Hotelling model so that it is too expensive for the larger firm to pre-empt poaching of its least loyal customers.

We believe that the inclusion of heterogeneous brand preferences to model competition in "switching markets" is problematic, however. 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 due to distance in product space; marginal consumers that firms compete over are located farther away from either firm and end-up paying a higher 'delivered' price. In contrast to this, the main competition concern raised in the context of consumer disengagement is that loyal “back-book” customers - those less likely to switch - arguably are the ones being exploited by their current provider and pay higher prices, compared to marginal, “front-book” customers. Indeed, a corollary of customer inertia due to the lack of engagement is, at least anecdotally, that customers fail to see that there are benefits from switching because they are under the impression that competing firms are undifferentiated.

We acknowledge that models with heterogeneously distributed switching costs tend to be isomorphic to Hotelling models with asymmetric transport costs, even when market shares are also asymmetric. We decided to cast our analysis in terms of switching costs, rather than brand preferences, because in the typical switching markets that were subject to CMA and FCA scrutiny and that contextualize our study brand preference does not appear to play a significant role.[10]

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. This is in contrast to the view that “challenger” firms, which start by definition with very small market shares, might be over-exposed to incumbents' “front-book” customers with low switching costs.

Accordingly, our approach is to directly model heterogeneous switching costs, rather than brand preferences. Moreover, in addition to Gehrig et al. [2012] we also analyse unilateral incentives to adopt BBPD. 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. 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.

Our analysis provides other novel insights. We show that, with heterogeneous switching costs across firms with asymmetric market shares, there are circumstances in which a challenger firm with small market share and a customer base with relatively low switching costs will prefer non-discriminatory pricing, even if faced with a larger incumbent with a customer

[10] 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 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.

base with relatively high switching costs. Hence, there is not always a prisoners' dilemma, in contrast to the Hotelling-based model of Thisse and Vives [1988]. In fact, we show that there exit even circumstances in which the challenger's poaching price exceeds the price charged to its locked-in customers. We also show that the incumbent may use history-based price discrimination as a means to deter entry by a uniform-pricing challenger.

Furthermore, our model of HBPD with leakage adds a new perspective on MFCCs. Unlike in Besanko and Lyon [1993], where MFCCs apply to all customers indiscriminately and thus act as a non-discrimination commitment device, in our setting the use of MFCCs amounts to a form of third-degree price discrimination. Here we find a different type of prisoners' dilemma, whereby both firms would be better off under the common use of MFCCs but none of them has a unilateral incentive to adopt MFCCs. In particular, an incumbent with high market shares and relatively high switching costs can anticipate that the smaller rival has strong incentives not to reciprocate but stick to the use of vanilla HBPD. Therefore, an asymmetric regulatory intervention aimed at imposing leakage only on the large incumbent would tend to favour the challenger firm.

The paper proceeds as follows. Section 2 details our modelling framework and its underlying assumptions. Section 3 characterises HBPD outcomes, which represents our baseline. Section 4 contrasts the results on HBPD with uniform pricing. In doing so, the section also explores the potential of price discrimination as a means for the incumbent to deter entry by a uniform-pricing challenger. Section 5 and 6 discusses HBPD with leakage and a peg, respectively. Section 7 provides a welfare comparison of the outcomes. And Section 8 concludes.

# 2 Model Setting and Assumptions

Suppose customers are spread uniformly on the unit interval, and two firms, $A$ and $B$, producing a homogeneous product, are located at $x_0$, so that $A$'s market share is $x_0 \in (0,1)$ and $B$'s market share is $1-x_0$. Market shares are taken as predetermined, but – as in Chen [1997] – it turns out that they do not matter when prices are discriminatory, except in cases when the heterogeneity of customer switching costs itself is tied to market shares and, it turns out, when prices are discriminatory, but subject to pegging constraints.

Unlike in Chen [1997]'s model where both firms' customers have uniformly and identically distributed switching costs, suppose customers of firm $A$ have switching costs $s_A$ that are distributed with CDF $\Phi_A(s)$ for $s \in \mathcal{S}_A \subseteq \mathbb{R}_+$, and customers of firm $B$ have switching costs $s_B$ with CDF $\Phi_B(s)$, $s \in \mathcal{S}_B \subseteq \mathbb{R}_+$. 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 $\Phi_A(s) = \Phi_B(s)$ 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 $\phi_A(s)$ and $\phi_B(s)$ exist.

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 firm $j$ loses when firm $i$ poaches firm $j$'s customers. Let $p_i$ denote firm $i$'s locked-in price, and $p_{ip}$ firm $i$'s poaching price, which can be thought of as $p_i$ net of an inducement $m_i$ that $i$ offers to $j$'s customers who switch to $i$. We assume throughout that consumers' valuations for the homogeneous product exceed prices.

We make the following assumptions.

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

$$\frac{\phi_A(s)}{\phi_B(s)} \geq \frac{\phi_A(t)}{\phi_B(t)} \quad \forall s \geq t; s \in \mathcal{S}_A, t \in \mathcal{S}_B.$$

The MLR assumption has been discussed and used widely in microeconomic theory [Athey, 2002, Lebrun, 1998, Maskin and Riley, 2000].

The MLR assumption implies that the distribution of firm $A$'s customers' switching costs $\Phi_A$ first-order stochastically dominates that of firm $B$'s customers' switching costs, i.e. $\Phi_A(s) \leq \Phi_B(s)$ for all $s \in \mathcal{S}_A \cup \mathcal{S}_B$.[11] It also implies that $\mathbb{E}[s_A] \geq \mathbb{E}[s_B]$.[12] So firm $A$'s customers are more likely to have higher switching costs than firm $B$'s, and their average switching costs are also higher. That suggests that firm $A$'s customers are more likely to be locked-in than firm $B$'s.

Furthermore, the MLR assumption implies the hazard rate (H) inequality:[13]

$$\frac{\phi_B(s)}{1 - \Phi_B(s)} \geq \frac{\phi_A(s)}{1 - \Phi_A(s)} \quad \forall s \in \mathcal{S}_A \cup \mathcal{S}_B.$$

This inequality implies that, for any $s$, firm $A$'s demand exhibits a lower own-price elasticity than firm $B$'s demand.

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

$$\frac{\phi_A(s)}{\Phi_A(s)} \geq \frac{\phi_B(s)}{\Phi_B(s)} \quad \forall s \in \mathcal{S}_A \cup \mathcal{S}_B.$$

This inequality, in turn, implies that, for any $s$, firm $A$'s demand lost to firm $B$ exhibits a

[11] 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 $\sup \mathcal{S}_B \leq \inf \mathcal{S}_A$.

[12] This follows from $\phi_B(t) s \phi_A(s) \geq \phi_A(t) s \phi_B(s)$, integrating w.r.t. $s$ and $t$ over $\mathcal{S}_A \cup \mathcal{S}_B$.

[13] This follows from rearranging and integrating w.r.t. $t$ up from $s$.

higher cross-price elasticity than firm $B$'s demand lost to firm $A$.

Consider two further assumptions.

**Assumption 2:** The hazard rates are weakly increasing, i.e.

$$\frac{\phi_i(s)}{1-\Phi_i(s)} \leq \frac{\phi_i(t)}{1-\Phi_i(t)} \quad \forall s \leq t; s, t \in \mathcal{S}_i, i = A, B.$$

This assumptions holds for the uniform distribution and the Weibull distribution with shape parameter greater than or equal to unity.[14] It implies that the firms' own-price elasticities are weakly increasing.

**Assumption 3:** The reverse hazard rates are weakly decreasing, i.e.

$$\frac{\phi_i(s)}{\Phi_i(s)} \geq \frac{\phi_i(t)}{\Phi_i(t)} \quad \forall s \leq t; s, t \in \mathcal{S}_i, i = A, B.$$

This assumption holds whenever the pdf is bounded. This assumption does not imply that the cross-price elasticities of the firm's lost demand are monotonic, however.

# 3 History-Based Price Discrimination

In this section we develop the baseline HBPD model. A Nash equilibrium in our setting involves firm specific prices $p$ and discounts $m$, $(p_A, p_B, m_a, m_B)$. Given these, firm $A$'s marginal customer has switching costs $\sigma_A = p_A - p_B + m_B$, and firm $B$'s marginal customer has $\sigma_B = p_B - p_A + m_A$. Therefore,

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

Assume firms have the same marginal cost $c$. Then, the firms' profits are given by

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

[14] The Weibull CDF is given by $F(s) = 1 - \exp(-\gamma s^\theta)$, for $s \in \mathbb{R}$ and scale parameter $\gamma > 0$ and shape parameter $\theta > 0$; $\theta = 1$ yields the exponential CDF. Its hazard rate is weakly increasing for $\theta \geq 1$ and decreasing for $\theta < 1$.

The firms' profit maximization problems yield the following first-order conditions,[15]

$$\begin{aligned}
p_A^* - c &= \frac{1-\Phi_A(\sigma_A^*)}{\phi_A(\sigma_A^*)} \\
p_B^* - c &= \frac{1-\Phi_B(\sigma_B^*)}{\phi_B(\sigma_B^*)} \\
p_A^* - c - m_A^* &= \frac{\Phi_B(\sigma_B^*)}{\phi_B(\sigma_B^*)} \\
p_B^* - c - m_B^* &= \frac{\Phi_A(\sigma_A^*)}{\phi_A(\sigma_A^*)},
\end{aligned}$$

where $p_i^*$ and $m_i^*$ denote firm $i$'s optimal price and discount, and $\sigma_i^* = p_i^* - p_j^* + m_j^*$, $i, j \in \{A, B\}$ and $i \neq j$. 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.[16]

The first-order conditions permit some initial insights into per-unit margins. They show that a firm's per-unit margin on retained customers is larger (smaller) than the per-unit margin of its rival on its poached customers if the marginal customer's switching cost is below (above) the median switching costs of its customer base. By the definition of $\sigma_A$ and $\sigma_B$ however, the first-order conditions imply

$$\begin{aligned}
\sigma_A^* &= \frac{1-2\Phi_A(\sigma_A^*)}{\phi_A(\sigma_A^*)} \\
\sigma_B^* &= \frac{1-2\Phi_B(\sigma_B^*)}{\phi_B(\sigma_B^*)},
\end{aligned}$$

and so in order for $\sigma_A^* \geq 0$ and $\sigma_B^* \geq 0$, it needs to be the case that both are no larger than the median of the respective switching cost distributions. Hence, the per-unit margin earned on retained customers exceeds the one earned by the rival on the firm's poached customers.

Defining the elasticity of firm $j$'s demand $q_{ij}$ accruing to firm $i$ with respect to firm $i$'s

[15]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 $\pi_A$ and $\pi_B$ with respect to $p_A$ and $p_B$, respectively.

[16]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 newer firms that can only grow 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.

price charged to firm $j$'s customers by $\epsilon_{q_{ij},p_{ji}}(\sigma_j)$, the first-order conditions imply

$$\begin{aligned}
\frac{p_A^* - c}{p_A^*} &= -\frac{1}{\epsilon_{q_{AA},p_A}(\sigma_A^*)} \\
\frac{p_B^* - c}{p_B^*} &= -\frac{1}{\epsilon_{q_{BB},p_B}(\sigma_B^*)} \\
\frac{p_A^* - c - m_A^*}{p_A^* - m_A^*} &= \frac{1}{\epsilon_{q_{AB},p_A - m_A}(\sigma_B^*)} \\
\frac{p_B^* - c - m_B^*}{p_B^* - m_B^*} &= \frac{1}{\epsilon_{q_{BA},p_B - m_B}(\sigma_A^*)}.
\end{aligned}$$

So the relative profit margins are seen to be inversely proportional to the own and cross price elasticities of the respective firm level demands for the marginal customers. This is noteworthy because it shows that any discount offered to specific groups of customers depends on the magnitude of the firm's own price elasticity of demand relative to the cross price elasticity of its rival's lost demand, for the respective marginal customers in equilibrium. Under our assumptions, we can obtain the following results.

**Lemma 3.1:** *Under Assumptions 1-3,* $\sigma_A^* \geq \sigma_B^*$.

*Proof:* Assumption 1 implies H and RH. Suppose the opposite were true, i.e. $\sigma_A < \sigma_B$. Then, by RH and Assumption 3, for $\sigma_A^* < s < \sigma_B^*$,

$$\frac{\Phi_A(\sigma_A^*)}{\phi_A(\sigma_A^*)} \leq \frac{\Phi_A(s)}{\phi_A(s)} \leq \frac{\Phi_B(s)}{\phi_B(s)} \leq \frac{\Phi_B(\sigma_B^*)}{\phi_B(\sigma_B^*)},$$

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

$$\frac{1-\Phi_B(\sigma_B^*)}{\phi_B(\sigma_B^*)} \leq \frac{1-\Phi_B(s)}{\phi_B(s)} \leq \frac{1-\Phi_A(s)}{\phi_A(s)} \leq \frac{1-\Phi_A(\sigma_A^*)}{\phi_A(\sigma_A^*)},$$

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

The Lemma has the interpretation that firm $A$'s marginal customer that firm $B$ induces to switch has a higher switching cost than firm $B$'s marginal customer.

The preceding Lemma is useful in order to establish the following

**Proposition 3.1:** *Under Assumption 4,* $p_B^* \leq p_A^*$*, and* $m_B^* \leq m_A^*$.

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

From the definitions of $\sigma_A$ and $\sigma_B$,

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

and from the first-order conditions,

$$\begin{aligned}
\sigma_A^* &= p_A^* - p_B^* + m_B^* = m_A^* + \frac{\Phi_B(\sigma_B^*)}{\phi_B(\sigma_B^*)} - \frac{\Phi_A(\sigma_A^*)}{\phi_A(\sigma_A^*)} \\
\sigma_B^* &= p_B^* - p_A^* + m_A^* = m_B^* + \frac{\Phi_A(\sigma_A^*)}{\phi_A(\sigma_A^*)} - \frac{\Phi_B(\sigma_B^*)}{\phi_B(\sigma_B^*)}.
\end{aligned}$$

Lemma 2.1, together with Assumption 3, implies that $\frac{\Phi_B(\sigma_B^*)}{\phi_B(\sigma_B^*)} - \frac{\Phi_A(\sigma_A^*)}{\phi_A(\sigma_A^*)} \leq 0$. Therefore, $0 \leq m_A^* - \sigma_A^* = \sigma_B^* - m_B^*$, and hence

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

□

The preceding result shows that, with heterogeneous switching costs, the firm with the more 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 model by Chen [1997], for the second period in a two-period game with payments for customers to switch, is a special case of this general framework, with $\phi_A(s) = \phi_B(s) = \frac{1}{\theta}1_{\{s\in[0,\theta]\}}$, $\theta > 0$.

# 4 Uniform Pricing

## 4.1 Characterisation of Uniform Pricing Outcomes

As explained in the introduction, uniform pricing may be re-instituted as the result of regulatory interventions banning the use of price discrimination altogether or imposing a duty on firms to move their existing customers on their best tariff. It is interesting to compare the history-based price discrimination outcome of Proposition 2.1 with a situation in which the firms charge uniform prices. In this situation, either some of firm $A$'s customer switch – if firm $A$'s uniform price $p_A^u$ exceeds firm $B$'s uniform price $p_B^u$ –, or some of firm $B$'s customers switch, but not both.

Consider the first of these two cases, with firm $A$'s marginal customer's switching cost $\sigma_A^u = p_A^u - p_B^u > 0$. Assume henceforth that $0 = \min\{s : s \in \mathcal{S}_A\} = \min\{s : s \in \mathcal{S}_B\}$. The firms' demands are then

$$\begin{aligned} q_A^u &= x_0 \left(1 - \Phi_A(\sigma_A^u)\right) \\ q_B^u &= 1 - x_0 + x_0 \Phi_A(\sigma_A^u). \end{aligned}$$

Clearly, only the distribution of switching costs of firm $A$'s customers who are at risk of switching matters in this case. The distribution of firm $B$'s customers' switching cost is immaterial.

The firms' profits are

$$\begin{aligned} \pi_A^u(p_A^u, p_B^u) &= (p_A - c) x_0 \left(1 - \Phi_A(\sigma_A^u)\right) \\ \pi_B^u(p_A^u, p_B^u) &= (p_B - c) \left(1 - x_0 + x_0 \Phi_A(\sigma_A^u)\right), \end{aligned}$$

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

$$\begin{aligned} p_A^{*u} - c &= \frac{1 - \Phi_A(\sigma_A^{*u})}{\phi_A(\sigma_A^{*u})} \\ p_B^{*u} - c &= \frac{1 - x_0 + x_0 \Phi_A(\sigma_A^{*u})}{x_0 \phi_A(\sigma_A^{*u})}. \end{aligned}$$

Therefore,

$$\begin{aligned} \sigma_A^{*u} &= p_A^{*u} - p_B^{*u} \\ &= \frac{2x_0 \left(1 - \Phi_A(\sigma_A^{*u})\right) - 1}{x_0 \phi_A(\sigma_A^{*u})}. \end{aligned}$$

The final equation shows that $x_0 \geq \frac{1}{2}$ is a necessary and sufficient condition for an equilibrium with $p_A^{*u} > p_B^{*u}$ to exist.[17]

The expression for $\sigma_A^{*u}$ also shows that $\sigma_A^{*_u}$ and hence the optimal uniform prices depend on $x_0$. In particular, if $\Phi_A$ has a relatively high probability mass on low values of $s_A$, then $\sigma_A^{*u}$ tends to be small, and the more so that the closer $x_0$ is 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.[18] While the situation of $\Phi_A$ (and / or $\Phi_B$) 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 lowering the switching costs of

[17] Note that $\sigma_A^u = 0$ implies that the righthand side is strictly positive for $x_0 > 0$, so that by continuity $\sigma_A^{*u} > 0$. Again, Chen [1997] provides a special case of this result.

[18] This is not an issue in models like Chen [1997] that assume homogeneous switching costs.

larger portions of consumers.[19]

Also, in that case, firm $B$ may be better off employing a price-discrimination strategy because it would allow it to target and segment consumers with different switching costs in its own customer base. It is easy to construct examples that exhibit that feature.

> *Example:* Suppose $\Phi_i(s) = 1 - \exp(-\gamma_i s^\alpha)$, $i = A, B$, with $\gamma_A = 4$, $\gamma_B = 3$, $\alpha = 1$ (i.e. exponential) and $x_0 = 0.55$.[20] Then, $p_A^* = \frac{1}{4}$, $p_B^* = \frac{1}{3}$, $m_A^* = 0.0759$, $m_B^* = 0.2159$, and $\pi_A = 0.1107$ and $\pi_B = 0.1196$; while $p_A^{*u} = \frac{1}{4}$ and $p_B^{*u} = 0.2342$, and $\pi_A^u = 0.1291$ and $\pi_B^u = 0.1133$. So firm $B$ would be better off if it could price discriminate, while the opposite is true for firm $A$.
>
> For comparison, if $\gamma_A = 3$ and $\gamma_B = 4$, i.e. $\Phi_A$ first-order stochastically dominates $\Phi_B$, then $p_A^{*u} = \frac{1}{3}$ and $p_B^{*u} = 0.3123$, with profits $\pi_A^u = 0.1721$ and $\pi_B^u = 0.1510$; with history-based price discrimination, $p_A^* = \frac{1}{3}, p_B^* = \frac{1}{4}, m_A^* = 0.2077$ and $m_B^* = 0.0896$, and profits $\pi_A = 0.1313$ and $\pi_B = 0.1041$. So in this case, both firms would be better off with uniform pricing.

The first part of the example shows that with heterogeneous switching costs and asymmetric historic market shares, in the terminology of Belleflamme and Peitz [2010] the competition and surplus extraction effects may operate differently for the two firms. And that may lead them to prefer different pricing strategies.

The second part of the example shows that there are circumstances in which both firms' uniform prices exceed those under HBPD, and both firms earn higher profits with uniform prices than with discriminatory prices. This is consistent with the finding that price discrimination under oligopoly can intensify pricing rivalry when competing firms exhibit best-response asymmetry in that they hold opposing views as to which consumers are strong and which are instead weak [Armstrong, 2006a].

Table 1 summarize the example and, in the second panel, provides a further illustration of the general Weibull case, with shape parameter $\theta = \frac{3}{2}$. Increasing the shape parameter moves probability mass towards the upper tail of the distribution. As a consequence, prices and profits rise relative to the exponential case.

The examples also illustrate the following proposition which states that, under our assumptions on heterogeneous switching costs, uniform prices exceed discriminatory prices, even for back-book customers.

**Proposition 4.1:** *Under Assumptions 1-3, $p_A^{*u} \geq p_A^*$ and $p_B^{*u} \geq p_B^*$.*

[19] For example, this may be thanks to interventions such as Open Banking which is meant to reduce the inconvenience of disengaged consumers when shopping around.

[20] Note that in this example, $\Phi_B$ first-order stochastically dominates $\Phi_A$.

*Proof:* It is sufficient to prove that $\sigma_A^{*u} \leq \sigma_A^*$ which implies, by the first-order conditions for firm $A$ and Assumption 2, that $p_A^{*u} \geq p_A^*$. This, together with $\sigma_A^* > \sigma_B^* > 0$ under HBPD, as shown in Lemma 2.1, by Assumption 2 implies also $p_B^{*u} \geq p_B^*$.[21]

Suppose to the contrary that $\sigma_A^{*u} > \sigma_A^*$. Then, $p_A^{*u} \leq p_A^*$ by the first-order conditions and Assumption 2. This ranking of prices of firm $A$, together with the supposition, implies also that $p_B^{*u} \leq p_B^* - m_B^*$.[22] Therefore, $p_B^{*u} - c \leq p_B^* - c - m_B^*$, and hence

$$\frac{1 - x_0 + x_0 \Phi_A(\sigma_A^{*u})}{x_0 \phi_A(\sigma_A^{*u})} \leq \frac{\Phi_A(\sigma_A^*)}{\phi_A(\sigma^*)}.$$

Notice that $x_0 = 1$ implies $\sigma_A^{*u} = \sigma_A^*$. Since the lefthand side of the inequality is decreasing in $x_0$, Assumption A3 implies that $\sigma_A^{*u} < \sigma_A^*$ for $\frac{1}{2} < x_0 < 1$, a contradiction to the supposition. $\square$

The Proposition shows that, if the large, established firm has a customer base that finds it relatively more costly to switch, compared to the challenger firm, then uniform prices are higher than prices for locked-in customers under HBPD. This result is of policy relevance as it is often argued that non-discriminatory interventions are aimed at protecting unengaged customers from exploitation. Our result shows that there exist circumstances in which such interventions would harm locked-in customers. As a purely technical matter, Assumption 1 is not needed for the determination of the uniform prices because only the distribution of firm $A$'s customers' switching costs matter.

This outcome may be surprising for policy practitioners, given the tendency to consider higher "lock-in" prices under HBPD as unfairly exploitative. We think that the key difference is that we rely on a smooth distribution of heterogeneous switching costs. The result would differ if the distribution of switching costs instead was neatly partitioned between two binary values, high and low switching costs. Under such a scenario, locked-in prices would arguably increase compared to uniform prices, as the rivals poaching price would not exert any constraint whatsoever.

Note that our argument implies that, while $\sigma_A^{*u} \leq \sigma_A^*$, for $x_0$ high enough $\sigma_A^{*u} \geq \sigma_A^* - \sigma_B^*$. So for high initial market share $x_0$, firm $A$ looses 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 sponsoring 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

[21] The situation of uniform prices is akin to $\sigma_B^* = 0$, i.e. none of firm $B$'s customers switch. Assumption 2 then implies that $p_B^*$ for $\sigma_B^* > 0$ is lower than the corresponding price if $\sigma_B$ were zero.

[22] This is because, under the supposition, $p_A^* - p_A^{*u} > p_A^{*u} - p_B^{*u} = \sigma_A^{*u} > \sigma_A^* = p_A^* - p_B^* + m_B^*$.

more. This result contrasts with Result 2 in Gehrig et al. [2011] that shows that the market 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, thereby insulating the smaller firm from poaching by its dominant rival.

## 4.2 Asymmetric Pricing: Price Discrimination as Entry Deterrence

We next examine whether a firm has an incentive to poach its rival's customers by unilateral price discrimination. We first focus on HBPD by the incumbent, vis-'a-vis a challenger with a uniform price. This case is of interest in its own right because there is a general view that firms applying HBPD have an advantage when meeting competition from firms applying uniform pricing. This instance is particularly relevant when evaluating the potential of HBPC by the incumbent as a means of deterring entry. An entrants, by definition, has no customer base, so on the part of the entrant there is no scope for price discrimination.[23] For example, Financial Conduct Authority [2015], Annex 1.4, mentions in particular that small cash savings providers typically treat existing and new customers equally and consider "teaser" rates and "new customers only bonus" deals offered by large incumbents as barriers to entry.

When the incumbent, firm $A$, price discriminates, while the challenger, firm $B$, applies a uniform price, then $p_A \geq p_B \geq p_A - m_A$, so that firm $A$'s marginal customer has switching costs $\sigma_A = p_A - p_B$, while firm $B$'s marginal customer has switching costs $\sigma_B = p_B - p_A + m_A$, i.e. switching occurs in both directions. Then,

$$
\begin{aligned}
q_{AA} &= x_0 \left(1 - \Phi_A(\sigma_A)\right) \\
q_{BA} &= x_0 \Phi_A(\sigma_A) \\
q_{BB} &= (1 - x_0) \left(1 - \Phi_B(\sigma_B)\right) \\
q_{AB} &= (1 - x_0) \Phi_B(\sigma_B),
\end{aligned}
$$

[23] 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, i.e. cuts in a uniform price to deter entry; and by Farrell and Shapiro [1988] who show that when an incumbent cannot price discriminate switching costs can actually promote entry. All-unit discounts - that apply once a buyer has exceeded a sales target - as a means of partial foreclosure has been considered by Chao et al. [2018] and Ide et al. [2016] in models with captive customers. Ordover and Shaffer [2013] consider exclusionary contracts between two asymmetric sellers and a single buyer in a two-period setting where the buyer incurs a switching cost when switching away from the first-period seller.

so that firms' profits are

$$\begin{aligned}\pi_A &= (p_A - c)x_0\left(1-\Phi_A(\sigma_A)\right) + (p_A - c - m_A)(1-x_0)\Phi_B(\sigma_B)\\ \pi_B &= (p_b - c)\left((1-x_0)\left(1-\Phi_B(\sigma_B)\right) + x_0\Phi_A(\sigma_A)\right).\end{aligned}$$

The profit maximizing prices then satisfy

$$\begin{aligned}p_A^* - c &= \frac{1-\Phi_A(\sigma_A^*)}{\phi_A(\sigma_A^*)}\\ p_A^* - c - m_A^* &= \frac{\Phi_B(\sigma_B^*)}{\phi_B(\sigma_B^*)}\\ p_B^* - c &= \frac{(1-x_0)\left(1-\Phi_B(\sigma_B^*)\right) + x_0\Phi_A(\sigma_A^*)}{(1-x_0)\phi_B(\sigma_B^*) + x_0\phi_A(\sigma_A^*)}.\end{aligned}$$

These, in turn, yield profits

$$\begin{aligned}\pi_A^* &= x_0\frac{\left(1-\Phi_A(\sigma_A^*)\right)^2}{\phi_A(\sigma_A^*)} + (1-x_0)\frac{\Phi_B(\sigma_B^*)^2}{\phi_B(\sigma_B^*)}\\ \pi_B^* &= \frac{\left((1-x_0)\left(1-\Phi_B(\sigma_B^*)\right) + x_0\Phi_A(\sigma_A^*)\right)^2}{(1-x_0)\phi_B(\sigma_B^*) + x_0\phi_A(\sigma^*A)}.\end{aligned}$$

When both firms price uniformly, profits are

$$\begin{aligned}\pi_A^{*u} &= x_0\frac{\left(1-\Phi_A(\sigma_A^{*u})\right)^2}{\phi_A(\sigma_A^{*u})}\\ \pi_B^{*u} &= \frac{\left(1-x_0+x_0\Phi_A(\sigma_A^{*u})\right)^2}{x_0\phi_A(\sigma_A^{*u})}.\end{aligned}$$

**Proposition 4.2**: *Under Assumptions 1-3,* $\pi_A^* < \pi_A^{*u}$.

*Proof*: Because unlike in the uniform pricing outcome firm $A$ poaches firm $B$'s customers, some of whom switch to firm $A$, $p_B^* < p_B^{*u}$ and $p_A^* \geq p_A^{*u}$. Hence, $p_A^* - p_B^* > p_A^{*u} - p_B^{*u}$ and so $\sigma_A^* > \sigma_A^{*u}$. By Assumption 2, it follows that the expected profit the incumbent firm $A$ makes on a retained customer is lower when the incumbent discriminates against a uniform pricing challenger than when $A$ responds with a uniform price, i.e. $\frac{\left(1-\Phi_A(\sigma_A^*)\right)^2}{\phi_A(\sigma_A^*)} < \frac{\left(1-\Phi_A(\sigma_A^{*u})\right)^2}{\phi_A(\sigma_A^{*u})}$. The reason is that the discriminatory price set to retained customers is set with respect to the more elastic portion of the expected demand curve of retained customers than under uniform pricing, because $\sigma_A^* > \sigma_A^{*u}$, hence the expected revenue from retained customers is lower. In contrast, with uniform pricing the incumbent sets the price such that the elasticity of expected demand of retained customers is smallest. This maximises expected revenue from retained customers.

The incumbent sets the poaching price, in turn, with respect to the expected demand from switching customers. Under our assumptions, their expected demand is uniformly more elastic than that for the incumbents' own customers, so the expected revenue obtained from switchers is lower than that from retained customers under uniform pricing.

The combined expected revenue is a convex combination of the expected revenues obtained from retained and poached customers and therefore is also lower. Hence, the incumbents best response to uniform pricing of the challenger is to set a uniform price as well. □

This result is illustrated by the last set of columns in Table 1 in the Weibull example.

It follows from Proposition 3.1 that the incumbent has an incentive to price discriminate when the challenger price discriminates. So for the incumbent, price discrimination is not always a dominant strategy.

For the challenger, in turn, poaching the incumbent's customers by means of a discriminatory, discounted price is a best response when $m_B^*$ in Proposition 1 satisfies $m_B^* > 0$. This is not necessarily the case. In fact, the third and fourth panel of Table 1 provide examples in which $m_B^* = 0$ – i.e. the challenger's optimal response to a price-discriminating incumbent is to charge a uniform price – and $m_B^* < 0$ – i.e. the challenger poaches the incumbent's customers with a price that exceeds the price charged to the challenger's locked-in customers.[24] Nonetheless, both outcomes are dominated by both firms charging a uniform price.

These outcomes differ from results like in Thisse and Vives [1988] where price-discrimination is always a dominant strategy for both firms. In our setting, except for special cases, a firm's best response to a given pricing strategy - uniform, vs. discriminatory - is to match it. However, the outcomes under uniform pricing dominate those under discriminatory pricing in terms of the expected profit they induce. [25] And in the case of asymmetric interventions whereby the non-discriminatory rule applies solely to the larger incumbent, the challenger

[24] We are indebted to Ken Hori for pointing this out.

[25] Unlike in Thisse and Vives [1988], consumer heterogeneity is due to different levels of switching costs which only switchers pay. Whereas, Thisse and Vives [1988] model consumer heterogeneity based on different levels of transport costs (i.e., as being geographically differentiated) which are borne by every consumer, so that delivered prices reflect different levels of transport costs for each consumer, depending on the consumer's and the firms' locations.

may choose to reciprocate by means of uniform pricing, rather than to stick to the use of HBPD.

> *Example:* (continued) For the case $\gamma_A = 3$ and $\gamma_B = 4$, with $x_0 = 0.55$, the prices are given by $p_A^u = 0.1915$, $p_B^L = \frac{1}{4}$ and $m_B = 0.1477$. These yield profits $\pi_A = 0.0986$ and $\pi_B = 0.1022$.

Finally, in order to investigate the incumbent's HBPD as an entry deterrence strategy, 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 $\tau$, suppose that the fraction of 'new' customers that the challenger can capture, $(1 - x_0)\tau$, to 'old' customers served by the incumbent, $x_0\tau$, is a constant $\kappa = \frac{1-x_0}{x_0}$, and that $\tau$ 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

$$\pi_B^*(\tau) = \tau \frac{\left(\kappa\left(1 - \Phi_B(\sigma_B^*)\right) + \Phi_A(\sigma_A^*)\right)^2}{\kappa\phi_B(\sigma_B^*) + \phi_A(\sigma_A^*)}.$$

Notice that

$$\begin{aligned} \sigma_A^* &= p_A^* - p_B^* = \frac{1 - \Phi_A(\sigma_A^*)}{\phi_A(\sigma_A^*)} - \frac{\kappa\left(1 - \Phi_B(\sigma_B^*)\right) + \Phi_A(\sigma_A^*)}{\kappa\phi_B(\sigma_B^*) + \phi_A(\sigma^* A)} \\ \sigma_B^* &= p_B^* - p_A^* + m_A^* = \frac{\kappa\left(1 - \Phi_B(\sigma_B^*)\right) + \Phi_A(\sigma_A^*)}{\kappa\phi_B(\sigma_B^*) + \phi_A(\sigma^* A)} - \frac{\Phi_B(\sigma_b^*)}{\phi_B(\sigma_B^*)}, \end{aligned}$$

i.e. the switching costs of the marginal customer depend on $\kappa$, but not on $\tau$.

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

$$\mathbb{E}\left[\pi_B^*(\tau)\right] = \mathbb{E}\left[\tau\right] \frac{\left(\kappa\left(1 - \Phi_B(\sigma_B^*)\right) + \Phi_A(\sigma_A^*)\right)^2}{\kappa\phi_B(\sigma_B^*) + \phi_A(\sigma_A^*)},$$

When the incumbent prices uniformly,

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

and this is seen to exceed $\mathbb{E}[\pi_B^*(x_0)]$.[26] So, as the challenger compares expected profit from entry with any sunk cost associated with entry, price discrimination on the part of the

[26] 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.

incumbent, as opposed to uniform pricing, erects a higher entry barrier for a uniform-pricing challenger.

# 5 Leakage (MFCCs)

By leakage we mean that a firm offers its inducement $m_j^L$, $j = A, B$, aimed at its rival's customers as in section 3, to its own customers as well. This can be viewed as a most-favoured customer clause (MFCC).[27] Some regulators, such as the FCA, consider encouraging this type of MFCC, e.g. by means of "disclosure remedies" [Financial Conduct Authority, 2018a] that aim at providing consumers with better information on the benefits of shopping around and switching provider.[28]

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 adopting an MFCC cannot discriminate between customers and must charge the same price to all customers. In our analysis, MFCCs are treated as an option offered to existing customers that they 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 only generates a small response in (internal) switching (Financial Conduct Authority [2015], Annex 1.2).[29] Another 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.

Suppose internal switching is only a fraction $\alpha \in (0, 1)$ as costly as external switching. In this setting, both firms offer a poaching price, below their respective regular price. Some customers of both firms switch internally to the sweetened tariff (internal switcher), 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.[30]

Denote the level of switching costs of the marginal internal switcher by $\sigma_j^i$, and the switching costs of the marginal external switcher by $\sigma_j^e$, $j = A, B$. Then, if $p_j^L$ denotes the

[27]See Akman and Hviid [2006] for a discussion of MFCCs from the perspective of competition law.

[28]For example, Financial Conduct Authority [2018a] considers a "return switching form [...], a simple 'tear-off' form and pre-paid envelope which would enable a customer to switch to a better paying [cash savings] account offered by their existing provider more easily (internal switching)."

[29]The "never knowingly undersold" best-price promise by some UK retailers provides another, similar example.

[30]This is shown in Lemma 4.2 below.

price charged to locked-in customers,

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

Therefore,

$$\begin{aligned} \sigma_j^i &= \frac{m_j^L}{\alpha} \\ \sigma_j^e &= \begin{cases} \frac{p_j^L - p_k^L - (m_j^L - m_k^L)}{1-\alpha} & \text{if } p_j^L - p_k^L - (m_j^L - m_k^L) > 0 \\ 0 & \text{o.w.} \end{cases}, \quad j,k = A,B; j \neq k. \end{aligned}$$

**Lemma 5.1:** $\sigma_j^i > \sigma_j^e$, $j = A, B$.

*Proof:* 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, $s' > s$, a contradiction. $\square$

**Lemma 5.2:** $\sigma_A^{*e} > 0$ *(and* $\sigma_B^{*e} = 0$*) if, and only if,* $x_0 \geq \frac{1}{2}$.

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

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

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

$$\begin{aligned}
\sigma_A^{*i} &= \frac{m_A^{*L}}{\alpha} = \frac{1-\Phi_A(\sigma_A^{*i})}{\phi_A(\sigma_A^{*i})} \\
\sigma_B^{*i} &= \frac{m_B^{*L}}{\alpha} = \frac{1-\Phi_B(\sigma_B^{*i})}{\phi_B(\sigma_B^{*i})} \\
\frac{p_A^{*L}-c-m_A^{*L}}{1-\alpha} &= \frac{1-\Phi_A(\sigma_A^{*e})}{\phi_A(\sigma_A^{*e})} \\
\frac{p_B^{*L}-c-m_B^{*L}}{1-\alpha} &= \frac{1-x_0+x_0\Phi_A(\sigma_A^{*e})}{x_0\phi_A(\sigma_A^{*e})}.
\end{aligned}$$

Therefore,

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

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

**Corollary 5.1:** $\sigma_A^{*e} = \sigma_A^{*u}$.

This corollary to Lemma 5.2 follows immediately from the last equality in the proof of the preceding lemma. It 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 uniform pricing.

**Proposition 5.1:** *Given $x_0 > \frac{1}{2}$ and Assumptions 1-3, $m_A^{*L} \geq m_B^{*L}$ and $p_A^{*L} \geq p_B^{*L}$.*

*Proof:* Assumptions 1-3 imply that the first two first-order conditions of the firms' profit maximization problem imply $\sigma_A^{*i} \geq \sigma_B^{*i}$, and hence $m_A^{*L} \geq m_B^{*L}$. Lemma 3 then implies that $p_A^{*L} - p_B^{*L} \geq 0$. □

*Example:* (continued) Suppose again that $\gamma_A = 4$ and $\gamma_B = 3$, and let $\alpha = 0.4$. Then, $m_A^{*L} = 0.1000$, $m_B^{*L} = 0.1333$, $p_A^{*L} = \frac{1}{4}$ and $p_B^{*L} = 0.2739$. So locked-in prices are no less than uniform prices. However, with $x_0 = 0.55$, this yields profits $\pi_A^L = 0.0977$ and $\pi_B^L = 0.0900$. So, compared to the outcome with uniform pricing and with history-based price discrimination, both firms are worse off.

In the case of $\gamma_A = 3$ and $\gamma_B = 4$, again with $\alpha = 0.4$ and $x_0 = 0.55$, $m_A^{*L} = 0.1333$, $m_B^{*L} = 0.1$, $p_A^* = \frac{1}{3}$ and $p_B^{*L} = 0.2874$, with profits $\pi_A^L = 0.1303$ and $\pi_B^L = 0.1072$. So compared to history-based price discrimination, firm $A$ is less profitable and firm $B$ is more profitable.

If internal switching is less costly, then in this example MFCCs become more profitable for both firms: With $\gamma_A = 3$, $\gamma_B = 4$ and $\alpha = 0.05$, $m_A^{*L} = 0.0167$, $m_B^{*L} = 0.0125$, $p_A^{*L} = \frac{1}{3}$ and $p_B^{*L} = 0.3092$, with profits $\pi_A^L = 0.1669$ and $\pi_B^L = 0.1455$. These are still less than those under uniform pricing, however. Leakage neutralises the toughening effect that the use of history-based price discrimination has on pricing rivalry, thanks to the fact that firms can use their poaching price as a defensive tool.

The example shows that, whether or not MFCCs are profitable, relative to history-based price discrimination without leakage, depends on the relative distribution of switching costs between the two firms and the level of the cost of internal switching. Indeed, when the costs of internal switching are very low, discriminatory prices are very close to those of the uniform case.

Table 2 adds results for the Weibull case with $\theta = \frac{3}{2}$ and $\alpha = 0.4$. Prices are higher than in the absence of leakage, and in this case both firms profit from MFCCs.

*Discussion: Unilateral Incentives*

Does either firm have an incentive to unilaterally impose an MFCC (i.e. to allow leakage), given its rival does not?

The example above shows that this question is only really relevant when the costs of internal switching are sufficiently low and when the distribution of switching costs disadvantages the larger firm. In this case, the larger, established firm's customers are at relatively higher risk of switching, and hence the larger firm would want to consider an MFCC as a defencin contrast to what motivated the intervention in the first placee. But that would mean that it will stem some of the outflow of customers to the challenger firm, while at the same time applying its lower poaching price to a large fraction of its remaining customer base. As $\alpha$ decreases, this fraction of the established firm's customer base increases, while the retention of marginal customers is eroded due to lower poaching prices of the challenger firm. So the established firm will earn less on a large fraction of its customer base and hence does not have an incentive to offer an MFCC unilaterally.

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 second-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. Therefore, the use of an MFCC amounts to a non-discrimination commitment device. In our model this corresponds to a setting under uniform pricing where $\alpha$ is equal to zero. The authors show that there can be configurations where firms have a unilateral incentive to use contemporaneous MFCCs. They also show that the use of contemporaneous MFCCs has a "band-wagon effect" whereby the more firms that adopt the practice in question, the more compelling it is for remaining firms to follow suit. Although our results are consistent with that effect, albeit only for a limited set of parameters, we find that the firms lack the incentives to trigger it in the first place.

On the one hand, the comparative analysis presented above suggests that the imposition of measures intended to encourage internal switching by regulators may well be detrimental to consumers, unless market shares are sufficiently skewed and/or the relative inconvenience of external switching is not too high. On the other hand, these results also suggest that firms might strategically react to the imposition of "leakage" by improving the relative convenience of their internal switching.

As a corollary, an asymmetric regulatory intervention whereby the imposition of "leakage" is solely directed at the larger firm can materially increase the smaller rival's profit, in particular for low values of $\alpha$, primarily at the expense of its locked-in customers, in contrast to what motivated the intervention in the first place.

# 6 Pegged Prices - Ratio-Based Price Regulation

Another regulatory intervention that has been proposed recently by the FCA is to constrain the dispersion of discriminatory prices, by pegging the magnitude of discounts to the level of the regular, undiscounted price. We model this as bounding the ratio between the regular and discounted prices, e.g. such that the discount $m_i$ is no more than a fraction $\beta \in (0, 1)$ of the regular price $p_i$, i.e. $m_i \leq \beta p_i$ for $i \in \{A, B\}$.

Adding the constraints $m_A \leq \beta p_A$ and $m_B \leq \beta p_B$ to the firms' profit maximization problems with HBPD, the solutions $p_A^{*P}, p_B^{*P}, m_A^{*P}, m_B^{*P}$ now satisfy

$$\begin{aligned}
p_A^{*P} - c &= \frac{1-\Phi_A(\sigma_A^{*P})}{\phi_A(\sigma_A^{*P})} - \lambda_A^* \frac{\beta - 1}{x_0} \\
p_B^{*P} - c &= \frac{1-\Phi_B(\sigma_B^{*P})}{\phi_B(\sigma_B^{*P})} - \lambda_B^* \frac{\beta - 1}{1 - x_0} \\
p_A^{*P} - c - m_A^{*P} &= \frac{\Phi_B(\sigma_B^{*P})}{\phi_B(\sigma_B^{*P})} + \lambda_A^* \frac{1}{1 - x_0} \\
p_B^{*P} - c - m_B^{*P} &= \frac{\Phi_A(\sigma_A^{*P})}{\phi_A(\sigma_A^{*P})} + \lambda_B^* \frac{1}{x_0},
\end{aligned}$$

where $\sigma_i^{*P}$ are defined analogously to $\sigma_i^*$ and $\lambda_i^* \geq 0$ are the Lagrange multipliers on the pegging constraints, $i \in \{A, B\}$. The Lagrange multipliers capture the increment to profits from slackening the pegging constraint, i.e. they are zero when the pegging constraints do not bind, and positive otherwise.

The first two first-order conditions imply that the regular, undiscounted prices $p_A^{*P}$ and $p_B^{*P}$ exceed their counterparts when the pegging constraint is binding. The second two first-order conditions imply that the discounted prices do as well. Hence, pegging discounts to prices tends to lift prices up. Because profits are the sum of two profit components, from retained and poached customers, both of which are linear in $x_0$ and $1 - x_0$ respectively, the marginal increment of profits form slackening the pegging constraint are also a sum of two components that are linear in $x_0$ and $1 - x_0$. Therefore, $\frac{\lambda_i^*}{x_0}$ decreases and $\frac{\lambda_i^*}{1-x_0}$ increases as $x_0$ increases, $i \in \{A, B\}$. Therefore, the uplift on the regular price of the incumbent is more muted and that for the challenger more accentuated the more entrenched the incumbent's position is; the converse applies to the discounted prices.

At the same time, clearly profits won't be higher than absent pegging: They are equal when the constraints do not bind, and they are smaller when they do.

Furthermore,

$$m_A^{*P} = \frac{1-\Phi_A(\sigma_A^{*P})}{\phi_A(\sigma_A^{*P})} - \frac{\Phi_B(\sigma_B^{*P})}{\phi_B(\sigma_B^{*P})} - \lambda_A^* \frac{(\beta-1)(1-x_0) + x_0}{x_0(1-x_0)}.$$

Because the inherited market share of the incumbent, $x_0$, exceeds the one of the challenger, $1 - x_0$, the numerator of the last ratio in the expression for $m_A^{*P}$ is negative, and hence the optimal level of the incumbent's discount $m_A^{*P}$ subject to the pegging constraint also exceeds the optimal discount absent pegging. Analogously, whether or not this is true for the challenger's discount $m_B^{*P}$ depends on whether $(\beta - 1)x_0$ is larger or smaller than $1 - x_0$.

Table 3 illustrates these results, for $\beta = 0.1$ and the Weibull example. The example also shows that, while it is still the case that profits under uniform pricing are highest, the gain in profit for the incumbent from unilaterally price discriminating subject to the constraint when meeting a uniform-pricing challenger are substantially larger than absent the peg.[31]

# 7 Welfare

In our analysis, consumer surplus is defined as the difference between the (unspecified) reservation valuation of the homogeneous good or service provided by the incumbent and challenger firm, net of price and switching costs for those consumers who switch provider. Therefore, ceteris paribus and comparing pricing regimes, higher prices and more entrenched lock-in mean reduced surplus. In this regard, it is important to recognise that the extent of consumer lock-in, or inertia, is endogenous because it is a function of the relative prices accessible to the respective consumer.

Table 4 shows the probabilities of consumer lock-in across the pricing regimes considered in our analysis. The top panel shows that uniform pricing entrenches consumer inertia compared to HBPD. Since uniform prices are also higher than discriminatory prices, HBPD dominates uniform pricing in terms of expected consumer welfare.

The middle panel shows that MFCCs facilitate internal switching and thereby reduce consumer lock-in internal to the firm, but through the equilibrium price adjustment which lifts up prices compared to HBPD induces only a small probability of external switching, so that the probabilities of consumer retention for the incumbent are approximately those under uniform pricing. So for consumers with high switching costs, MFCCs can be welfare reducing compared to HBPD, because their inability to switch means that they pay higher prices.

The bottom panel shows that ratio-based price regulation also entrenches consumer lock-in. As the equilibrium adjustment to this type of constraint on prices is also to lift prices above those under HBPD, ratio-based price regulation would also be expected to reduce welfare.

So if the consumer protection objective is to safeguard consumer surplus of vulnerable consumers who do not switch, HBPD absent any constraint emerges as the preferable regime. But as shown in Section 4.2, a potential entrant who does not yet have the ability to price discriminate and therefore charges a uniform price may not expect to earn profits that suffice to cover any entry or set-up costs. If HBPD on the part of the incumbent precludes entry by a challenger, then the consumer protection objective stands in conflict with the competition policy objective of promoting competition for and in the market.

[31] 0.38 vs. 0.09, as opposed to 0.22 vs. 0.18.

# 8 Conclusions

This paper studies options for price regulation to protect vulnerable consumers in asymmetric oligopolistic markets where firms' customers have heterogeneous switching costs. We show that in a setting with asymmetric market shares and heterogeneous switching costs price-discrimination can be beneficial for consumers; that there exist circumstances where the challenger may find uniform pricing a best response to a price-discriminating incumbent; and where the challenger's poaching price may exceed the price charged to its locked-in customers; and that, unlike in a class of product-preference based models, price discrimination is not a dominant strategy. We also demonstrate that when internal switching is significantly more convenient than external switching to a rival firm disclosure remedies in the form of price discrimination with leakage, or MFCCs, might dissipate much of the benefits of price discrimination. The same is true in our setting for ratio-based price regulation.

Furthermore, we show that history-based price discrimination by an incumbent can deter a challenger's entry. This finding, in turn, implies that consumer protection objective may be in conflict with competition objectives.

Our results are policy relevant. They evaluate the array of interventions at the disposal of consumer protection agencies, in a setting with asymmetric market shares and heterogeneous switching costs that are salient characteristics of many markets that have come or are under regulatory scrutiny. And they will also become relevant for competition bodies, such as the CMA, in light of the re-examination of legislative frameworks that aim at strengthening competition regimes to better protect the vulnerable.[32]

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[32]See, for example, the CMA's Annual Plan 2018-19 that defines helping vulnerable people as one of the CMA's strategic priorities.

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Table 1: **Example: Weibull Distribution** $F(s) = 1 - \exp(-\gamma s^{\theta})$

| Firm | Param. | UP | Profit | HBPD[a] | Profit | UI[b] | Profit |
|---|---|---|---|---|---|---|---|
| incumbent | $\gamma = 3$ | 0.33 | 0.17 | 0.33 | | 0.33 | |
| | $\theta = 1$ | | | 0.12 | 0.13 | 0.11 | 0.14 |
| challenger | $\gamma = 4$ | 0.31 | 0.15 | 0.25 | | 0.21 | 0.10 |
| | $\theta = 1$ | | | 0.16 | 0.10 | | |
| incumbent | $\gamma = 3$ | 0.85 | 0.44 | 0.43 | | 0.49 | |
| | $\theta = \frac{3}{2}$ | | | 0.14 | 0.18 | 0.12 | 0.22 |
| challenger | $\gamma = 4$ | 0.78 | 0.37 | 0.36 | | 0.29 | 0.14 |
| | $\theta = \frac{3}{2}$ | | | 0.17 | 0.14 | | |
| incumbent | $\gamma = 1$ | 1 | 0.52 | 1 | | | |
| | $\theta = 1$ | | | 0.31 | 0.40 | | |
| challenger | $\gamma = \frac{9}{5}$ | 0.94 | 0.45 | 0.56 | | | |
| | $\theta = 1$ | | | 0.56 | 0.27 | | |
| incumbent | $\gamma = 1$ | | | 1 | | | |
| | $\theta = 1$ | | | 0.56 | | | |
| challenger | $\gamma = 5$ | | | 0.2 | | | |
| | $\theta = 1$ | | | 0.56 | | | |

Incumbent market share: 0.55. Marginal cost $c = 0$. [a] In the column labelled HBPD, for each firm the top price refers to $p^*$, while the bottom price refers to $p^* - m^*$. [b] The column labelled UI refers to the analysis of unilateral incentives, with the incumbent price discriminating and the challenger charging a uniform price.

Table 2: **Example: Weibull Distribution**

| Firm | Param. | HBPD | Profit | MFCC $\alpha =$ | Profit 0.4 | MFCC $\alpha =$ | Profit 0.05 |
|---|---|---|---|---|---|---|---|
| inc. | $\gamma = 3$ | 0.33 | | 0.33 | | 0.33 | |
| | $\theta = 1$ | 0.12 | 0.131 | 0.20 | 0.130 | 0.31 | 0.167 |
| chal. | $\gamma = 4$ | 0.25 | | 0.29 | | 0.31 | |
| | $\theta = 1$ | 0.16 | 0.104 | 0.19 | 0.107 | 0.30 | 0.146 |
| inc. | $\gamma = 3$ | 0.43 | | 0.66 | | | |
| | $\theta = \frac{3}{2}$ | 0.14 | 0.18 | 0.51 | 0.272 | | |
| chal. | $\gamma = 4$ | 0.36 | | 0.51 | | | |
| | $\theta = \frac{3}{2}$ | 0.17 | 0.14 | 0.47 | 0.217 | | |

Incumbent market share: 0.55. Marginal cost $c = 0$.

Table 3: **Example: Weibull Distribution**

| Firm | Param. | UP | Profit | HBPD[a] | Profit | PPD[b] | Profit | UI[c] | Profit |
|---|---|---|---|---|---|---|---|---|---|
| incumbent | $\gamma = 3$ | 0.85 | 0.44 | 0.43 | | 0.53 | | 0.73 | |
| | $\theta = \frac{3}{2}$ | | | 0.14 | 0.18 | 0.48 | 0.09 | 0.66 | 0.38 |
| challenger | $\gamma = 4$ | 0.78 | 0.37 | 0.36 | | 0.50 | | 0.66 | 0.32 |
| | $\theta = \frac{3}{2}$ | | | 0.17 | 0.14 | 0.45 | 0.02 | | |

Incumbent market share: 0.55. Marginal cost $c = 0$. [a] In the column labelled HBPD, for each firm the top price refers to $p^*$, while the bottom price refers to $p^* - m^*$. [b] HBPD subject to the constraint that the discount is limited to 10 percent of the regular price ($\beta = 0.1$). [c] The column labelled UI refers to the analysis of unilateral incentives, with the incumbent price discriminating subject to the peg with $\beta = 0.1$, and the challenger charging a uniform price.

Table 4: **Probabilities of Lock-In**

| Regime | incumbent $\gamma = 3$ $\theta = 1$ | challenger $\gamma = 4$ $\theta = 1$ | incumbent $\gamma = 3$ $\theta = \frac{3}{2}$ | challenger $\gamma = 4$ $\theta = \frac{3}{2}$ |
|---|---|---|---|---|
| HBPD | 0.60 | 0.59 | 0.67 | 0.66 |
| UP | 0.94 | 1 | 0.95 | 1 |
| UI | 0.70 | 0.67 | 0.76 | 0.75 |
| MFCC[a] $\alpha = 0.4$ | 0.38 | 0.37 | 0.93 | 0.88 |
| | 0.95 | 1 | 0.95 | 1 |
| MFCC $\alpha = 0.05$ | 0.55 | 0.45 | | |
| | 0.94 | 1 | | |
| PPD | | | 0.93 | 0.99 |
| UI | | | 0.95 | 1 |

Incumbent market share: 0.55. Marginal cost $c = 0$. Probabilities of lock-in calculated for the Weibull examples in Tables 1-3. [a] In the rows for MFCCs, the top entries refer to the probabilities of internal lock-in, and the bottom entry to the probability of customer retention.