BANK OF ENGLAND

Staff Working Paper No. 689

Spatial models of heterogeneous switching costs

Paolo Siciliani and Walter Beckert

November 2017

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Abstract

The presence of sticky, often labelled 'unengaged', consumers is arguably one of the most intractable issues faced by competition regulators, in that it entrenches incumbency advantage. We develop a spatial linear model of heterogeneous switching costs that allows for asymmetric distributions of heterogeneous switching costs. We not only model uniform pricing and history-based price discrimination, but also the impact of regulatory intervention aimed at making it easier for customers to be upgraded to a better tariff from their current service provider, something we call 'leakage'. Finally, we analyse firms' incentive to adopt history-based price discrimination and voluntarily permit 'leakage'.

Key words: Switching costs, unengaged 'sticky' customers, spatial linear model, uniform pricing, history-based price discrimination, 'leakage'.

JEL classification: D43, L11, L44.

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The views expressed in this paper are those of the authors, and not necessarily those of the Bank of England or its committees. We are grateful to Nora Wagner and Kristoffer Milonas for the useful initial discussions. We thank Paul Grout, Stephen Dickinson, Bill Francis and participants at 2017 EARIE Conference (Maastricht, 1 September) and at the CMA seminar (25 September) for useful comments.

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Telephone +44 (0)20 7601 4030 email publications@bankofengland.co.uk

ISSN 1749-9135 (on-line)

Introduction

The presence of sticky, often labelled "unengaged", consumers who do not switch from their current service provider is arguably one of the most intractable issues faced by competition authorities.[1] Large oligopolistic incumbents are said to enjoy an unfair competitive advantage by virtue of a large proportion, often labelled a "back-book", of loyal customers who are typically more profitable to serve than more active customers who regularly shop around in search for a better deal and who are willing to switch. Therefore, small firms, often labelled "challengers", face barriers to entry and expansion due to higher customer acquisition costs and the risk that the make-up of their customer base is overexposed towards customers with a high propensity to switch.[2] This is why competition authorities, particularly in the UK, have proposed a set of remedies aimed at lowering consumer search and switching costs in order to address the underlying customer disengagement and resulting inertia.[3]

However, trust in the effectiveness of these measures, which typically rely on the expectation that consumers would shop around if only they were provided with proper advice, is shaky in the face of persistent unresponsiveness by a large chunk of consumers. This is particularly frustrating given that the types of services typically affected are utilities such as retail energy, basic telecoms services and retail financial services such as current accounts, that is, essential services that every consumer must purchase; meaning that the extent of consumer detriment is potentially very large.[4] Hence, there are calls for a more interventionist approach aimed at regulating prices at the retail level.[5]

Similarly to brand preferences, search and switching costs are a source of market power because rivals have to discount their prices by a larger amount in order to, respectively, capture rival customers' attention and compensate them for the costs that would be

[1] The two most prominent examples are the two market inquiries in retail banking and retail energy recently completed by the UK Competition and Markets Authority: see CMA (2016a, 2016b)
[2] See, CMA (2016a: para. 9.282 at p. 397).
[3] See, for example, FCA (2016a).
[4] For example, in the energy market investigation the CMA estimated that the detriment from excessive prices to UK consumers in 2015 was almost £2 billion (CMA, 2016b, para. 194 at p. 46). Similarly, with respect to the purchase of current account services, the CMA estimated that if all customers who would benefit from doing so switched to a cheaper product, there could be around £4.6 billion gains per year for customers (CMA, 2016a, para. 11.26 at p. 431).
[5] In the latest example in the UK, the Prime Minister announced a new draft Parliamentary bill aimed at capping retail energy prices: see, *Theresa May revives plan to cap energy prices*, BBC News (online), 4 October 2017, available at http://www.bbc.co.uk/news/business-41499483. Similarly, with respect to retail banking, in particular personal current accounts, the financial regulator clearly signalled the intention to rule out the use of unarranged overdrafts and potentially cap the fees for arranged overdrafts, in a radical departure from the approach previously endorsed by the competition authority which refused to regulate prices directly: compare *Andrew Bailey speech on retail banking in the UK - reflections from the FCA*, 29 June 2017, available at https://www.fca.org.uk/news/speeches/andrew-bailey-speech-retail-banking-uk-reflections-fca; with *Alasdair Smith on competition and Open Banking*, 29 June 2017, available at https://www.gov.uk/government/speeches/alasdair-smith-on-competition-and-open-banking.

incurred upon switching. In turn, this allows the current provider to charge higher prices to 'locked-in' customers.

However, the analogy with brand preferences may be misleading. Under the Hotelling linear approach to model brand preferences,[6] loyal customers identified as those closer to their current firm's location, typically located at one of the extremes of the linear market, are the ones paying the lowest 'delivered' price, that is, inclusive of the 'transport' cost which captures brand dissatisfaction. In contrast, those consumers located away from either firm who are thus more likely to switch end-up paying a higher 'delivered' price, possibly also including a switching cost. Whereas, the main competition concern raised in circumstances as those outlined at the beginning of this introduction is that sticky customers – those less likely to switch - are the ones being exploited by their current provider. Indeed, a corollary of customer inertia due to the lack of engagement is that customers fail to see that there are benefits from switching because they are under the impression that competing firms are similar and that they all deliver poor value-for-money.

Another feature of the classic spatial linear model of horizontal differentiation that does not fit the stylised facts depicted above is that the 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 predominantly of very loyal customers who face a very high 'transport' cost to switch to the rival firm located further away at the opposite end of the linear market. This is in contrast to the view that 'challengers' may end up attracting a disproportionate amount of (marginal) consumers who are more likely to switch again and are therefore less profitable to retain.

Therefore, when the analysis of the impact of switching costs is based on the Hotelling linear framework, as it is the case in much of the recent literature on this subject,[7] it is difficult to disentangle the effects due to the presence of switching costs with those due to the presence of brand preferences.

The approach developed in this paper differs in that we adapt the spatial linear framework to model directly the presence of heterogeneous switching costs, rather than brand preferences. Moreover, this approach allows us to also model an asymmetric distribution of heterogeneous switching costs across firms with asymmetric market shares. The second novel feature in this paper is that we not only model competition under both uniform pricing and history-based price discrimination (a form of third-degree price discrimination), but also consider the impact of regulatory intervention

[6] Under the linear Hotelling framework firms are located typically at the extremes of the unit interval, and the distances from these locations denote the extent to which customers located along the unit interval dislike the offer from the corresponding firm. In other words, the closer a customers is located to each one of the two firms, the stronger is her preferences for the firm in question compared to the rival firm which is located far away on the other end of the line.
[7] For example, Fabra and Garcia (2015); Somaini and Einav (2013); Rhodes (2014); Pearcy (2015); Cabral (2016).

aimed at making it easier for sticky ('back-book') customers to benefit from the superior offers introduced by their current service provider to acquire new customers, something which we label as 'leakage', in the sense that this kind of intervention aimed at boosting 'internal' switching tends to inflate firms' customer acquisition costs. Finally, we analyse firms' unilateral incentives to depart from the common use of uniform pricing by adopting history-based price discrimination, and to depart from the common use of uniform pricing by voluntarily permitting 'leakage'. The latter move can be conceptualised as adopting a most-favoured-customer clause (MFCC) where customers face heterogeneous 'hassle' costs to claim for compensation.

We fully characterise equilibrium outcomes, including consumer surplus. Switching costs are unambiguously anti-competitive. Levels of switching are unrelated to the magnitude of switching costs, so that the anticompetitive effect only materialises in terms of higher prices. Under uniform pricing, external switching only occurs in one direction from the firm with the larger market share to the rival firm with the smaller one. There is no switching when market shares are symmetric to start with. Under history-based price discrimination, switching across firms occurs in both directions, although to a larger extent from the larger to the smaller firm. Finally, with 'leakage', switching across firms only occurs in one direction as under uniform pricing, but there is switching within firms in both directions.

We also find that the use of price discrimination is beneficial to all consumers when compared to the regime under uniform prices. This is the case with respect to both "back-book" and "front-book" customers. This is in contrast to the often heard argument that the use of history-based price discrimination might have a distributional implications whereby "front-book" customers are subsidised by "back-book" ones.

However, it is not clear why firms would want to start (unilaterally) price discriminating in the first place. Indeed, in contrast to Thisse and Vives (1988), the most plausible explanation for the symmetric adoption of history-based price discrimination is neither the Prisoners Dilemma nor anti-competive foreclosure, but the mutually reinforcing reaction to the risk of being unilaterally exposed to it.

The imposition of 'leakage' can (unintentionally) dilute consumer benefits from the use of history-based price discrimination when 'internal' switching is much more convenient than switching 'externally' to a competitor. In the absence of regulatory intervention, 'leakage' can only arise when the smaller firm takes a risk by moving first, in the hope that the larger rival will follow suit rather than choosing not to increase its profit in order to weaken the smaller rival, that is, akin to profit sacrifice. As a corollary, asymmetric regulatory intervention which mandates 'leakage' only for the larger firm greatly benefits smaller rivals, whose profit is much higher by not following suit to the detriment of its 'locked-in' customers.

This paper contributes to the literature on the impact on competition due to the presence of switching costs. It is well established that the presence of switching costs can lead firms to adopt dynamic pricing strategies labelled 'bargain-then-rip-off' pricing, whereby promotional low prices are followed by high ones to exploit 'locked-in' customers.[8] However, to the extent that consumers are alert to this pricing pattern, they should be less responsive to the use of promotional low prices. This is particularly the case when switching costs are high (Rhodes, 2014). If firms are unable to price discriminate between new and current customers, the incentive to exploit current customers entails that firms with larger market shares charge higher prices. Over time this pricing pattern should tend to reduce market share asymmetries as larger firms are less keen on acquiring new unattached customers (Beggs and Klemperer, 1992) or poaching rivals' customers (Rhodes, 2014; Somaini and Einav, 2013).

Gehrig et al. (2012) found 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. This is because the authors also include brand preferences under a linear Hoteling model so that it is too expensive for the larger firm to pre-empt poaching of its least loyal customers, thus making it easier for the smaller rival to grow market share whilst still exploiting its most loyal customers thanks to price discrimination.

Recent contributions to the literature have called into question the conventional wisdom that higher switching costs always lead to higher prices on average. Starting from very low switching costs, and where consumers also have heterogeneous brand preferences, an increase in switching costs can lead to a reduction in prices, because the anticipated benefits from enticing new customers with low prices - with a view to then exploiting them once they are locked-in - become greater (Fabra and Garcia, 2012; Somaini and Einav, 2013; Rhodes, 2014; Pearcy, 2015; Cabral, 2016). Biglaiser et al. (2013; 2016) obtain a similar result but under heterogeneous switching costs instead of heterogeneous brand preferences. The authors find that a reduction in switching costs for low-switching-cost consumers will tend to make high-cost consumers less likely to switch. This is because the latter anticipate that the poaching firm will want to solely exploit them, rather than setting a lower price in order to also retain the former. By the same token, an increase in the number of low-switching-cost consumers, whilst keeping the number of high-switching-cost consumers fixed, increases the profit of the incumbent firm, which ends up specialising in selling only to high-cost ones, whereas challenger firms are forced to acquire a higher number of unprofitable low-cost consumers first, who will always be ready to switch elsewhere as soon as prices are increased.

This paper also expands on the insights from Thisse and Vives (1988) who showed that, under a Hotelling linear framework, duopolist firms face a Prisoners Dilemma in that they would be collectively better off by commonly committing to the use of uniform

[8] See Farrell and Klemperer (2007) for a literature review.

pricing, but end up both adopting history-based price discrimination because the loss of profit for being (unilaterally) exposed to a rival using it is too large. We show that, in the absence of brand preferences à la Hotelling, firms never have an incentive to unilaterally adopt price discrimination, as the response of the rival still using uniform prices will nevertheless impair the firm's ability to extract rents from its own customers.

Finally, this paper adds to the insight from Besanko and Lyon (1993) who analysed firms' incentives to adopt contemporaneous MFCCs where consumers are partitioned between 'non-shoppers', who never consider switching, and 'shoppers', who have no brand preference. In their model the MFCC applies to every customer indiscriminately. Therefore, the use of an MFCC amounts to a non-discrimination commitment device. In contrast, in our setting the use of contemporaneous MFCC when consumers face heterogeneous 'hassle costs' to exercise their right is tantamount to a form of second-degree price discrimination.

The next section develops the models under the three pricing regimes: uniform pricing; history-based price discrimination; and history-based price discrimination with 'leakage'. Section 2 compares and discusses the equilibrium outcomes. Section 3 concludes.

1 The model

There are two firms $i = \{A, B\}$ with no fixed cost, no capacity constraints and constant marginal costs which are normalised to zero. There is a continuum of customers with unit demand for a product and common valuation V which is large enough to guarantee full market coverage. Customers are uniformly distributed along the unit interval with location $x \in [0,1]$. Both firms are located at $x_0 \in [0,1]$, whereby customers located in the interval $[0, x_0]$ are attached to firm A and those in the interval $[x_0, 1]$ are attached to firm B. This means that when $x_0 = \frac{1}{2}$ firms have inherited symmetric market shares. Customers have heterogeneous switching costs, based on the common parameter $s > 0$,[9] which are linear in their distance from x_0: that is, $s|x_0 - x|$.

This configuration entails that mean switching costs across firms' customer bases depends on the corresponding market shares. Whilst this modelling choice may at first appear as restrictive, the intention is to portray the competition distortions highlighted in the introductory section. The underlying intuition is that, where inherited market shares are asymmetric, the larger firm benefits from a 'back-book' of sticky/unengaged customers who have higher switching costs; whereas the customer base of the smaller firm is made of comparatively more active customers on average, for example, as it would be the case with a 'challenger' new entrant. In what follows we first present and

[9]This entails that, as is standard in the literature, consumers switching costs do not depend on the identity of the firm they are attached to.

then compare three different treatments, depending on which pricing strategy firms adopt.

1.1 Uniform pricing

Firms can only set uniform prices p_{iu}. Customers can choose to buy from the same firm as in the previous period - say, firm A - or they can switch to the other firm B by incurring a switching cost. Therefore, the objective function of a customer located at $x \leq x_0$ is given by:

$$max\{V - p_{Au}, V - p_{Bu} - s(x_0 - x)\}.^{10} \tag{1}$$

Accordingly, the location of the customer who is indifferent between the two firms is given by (later on simply labelled cut-off point):

$$V - p_{Au} = V - p_{Bu} - s(x_0 - x) \rightarrow x = x_o + \frac{p_{Bu} - p_{Au}}{s} \equiv x_1. \tag{2}$$

Figure 1 illustrates this framework.

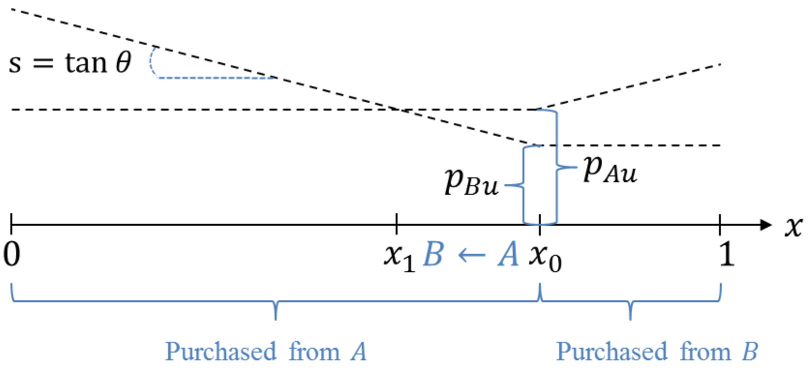

Fig. 1: spatial model of switching costs with uniform pricing.

The black-dotted lines delineate prices inclusive of switching costs.[11] Accordingly, the sloping segments represent the 'delivered' price from the perspective of consumers attached to the other firm. In the example above firms have inherited asymmetric market shares, so that the smaller firm B sets a lower price in order to poach some of its rival's customers. Accordingly, the intersection between the sloping line projecting from the lower price and the flat line corresponding to the higher price identifies the cut-off point on the horizontal axis. Hence, under uniform pricing there is a mean-reverting tendency whereby switching is unidirectional from the larger firm to the smaller one.[12]

[10] It is important to note that the switching cost is only incurred in case of switching, that is, in contrast to the traditional spatial models where the 'transport' cost, which depends on the distance from the firm's location, is incurred regardless.
[11] Total switching costs are linear to the distance from x_0, which graphically entails that the tangent of the angle formed by the slanted dotted line is equal to the switching cost parameter s. In other words, s is the slope.
[12] This is a standard result in the literature on switching costs: see, for example, Rhodes (2014); Somaini and Einav (2013); and Gehrig et al. (2012, Section 4).

Formally, firms' profits under uniform pricing are given by:

$$\pi_A^U = p_{Au}\left(x_0 + \frac{p_{Bu}-p_{Au}}{s}\right) \text{ and} \tag{3a}$$

$$\pi_B^U = p_{Bu}\left(1 - x_0 - \frac{p_{Bu}-p_{Au}}{s}\right). \tag{3b}$$

To note that the last term in the quantity expressions within brackets is the same for both firms and can be either positive or negative depending on whether the firm in question is undercutting the rival in order to 'poach' some of its customers or vice versa.

Solving the system of first order conditions (FOCs), $\frac{\partial \pi_i^U}{\partial p_{iu}} = 0$,[13] leads to:

$$p_A^U = \frac{s(x_0+1)}{3} \text{ and} \tag{4a}$$

$$p_B^U = \frac{s(2-x_0)}{3}. \tag{4b}$$

Figure 2 illustrates how equilibrium prices vary with respect to x_0:

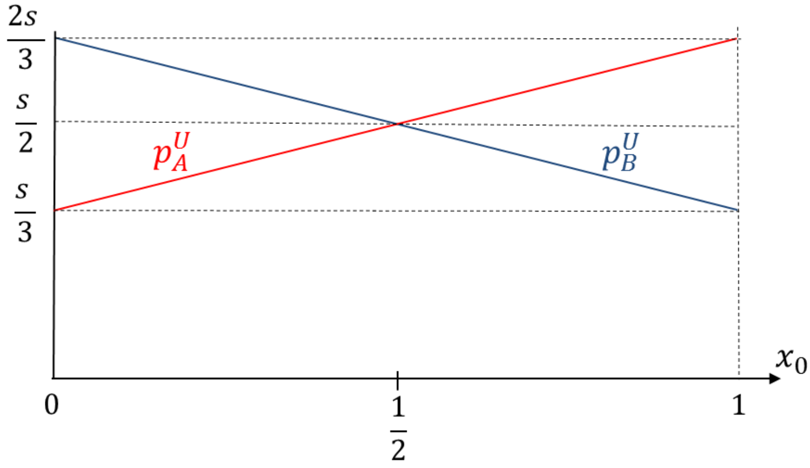

Fig. 2: equilibrium prices under uniform pricing.

The larger the inherited market share the higher the uniform price charged, that is, as the 'harvesting incentive' dominates over the opposing 'investment incentive'. The maximum difference between prices occurs at the two extremes of the line – that is, when one firm is a monopolist and the rival a new entrant – and is equal to one third of the switching cost parameter. With equal market shares ($x_0 = \frac{1}{2}$) prices are the same.

The equilibrium cut-off point is given by:

$$x_1^U = \frac{x_0+1}{3}. \tag{5}$$

[13] It is straightforward to verify that the second order conditions are satisfied.

This expression is growing in x_0 (although less than proportionally), does not depend on s, and is mean reverting towards $\frac{1}{2}$. That is to say, the middle point is stable, where no switching takes place. The observation that the expression for x_1^U does not depend on the switching cost parameter s is perhaps counterintuitive, in that a reduction in switching cost does not lead to an increase in the volume of switching, which instead depends solely on the distribution of market shares, but to a reduction in prices.

Graphically:

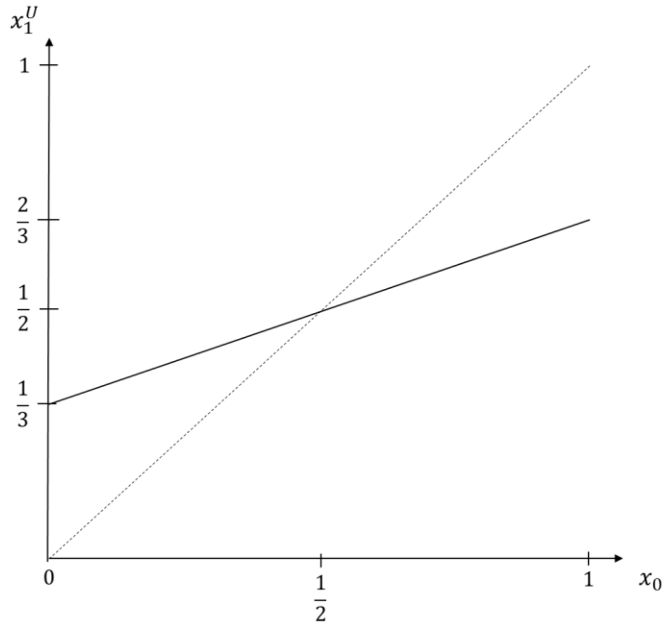

Fig. 3: mean reversion property of equilibrium quantity.

The difference with the 45-degree dotted line indicates the amount of switching away from the firm with the larger market share. Accordingly, no switching takes place when inherited market shares are the same.

Equilibrium profits are given by:

$$\pi_A^U = \frac{s(x_0+1)^2}{9} = \frac{{p_A^U}^2}{s} \text{ and} \tag{6a}$$

$$\pi_B^U = \frac{s(2-x_0)^2}{9} = \frac{{p_B^U}^2}{s}, \tag{6b}$$

which, over the interval $x_0 \in [0,1]$, are specular semi parabolic curves and, respectively, increasing and decreasing in x_0, besides being both increasing in s. Graphically, with respect to x_0 (and by setting $s = 1$):

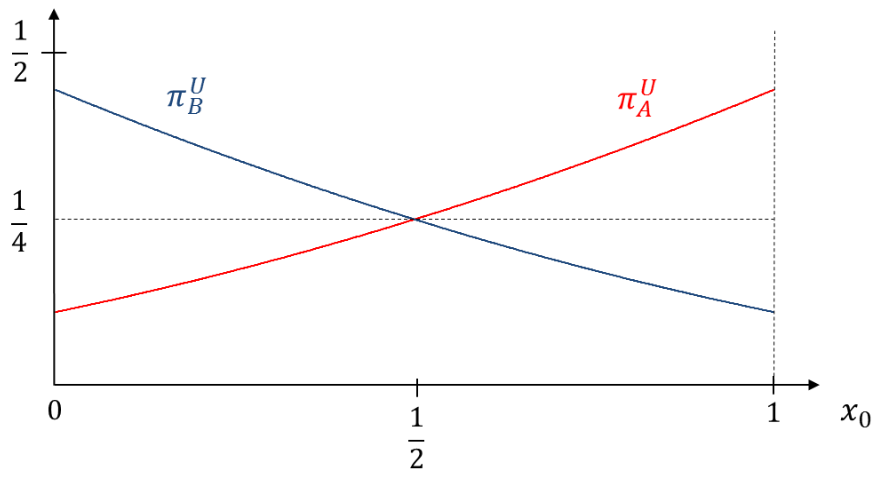

Fig. 4: equilibrium profits under uniform pricing.

Finally, the expressions for consumer surplus when $x_0 \leq \frac{1}{2}$ and $x_0 \geq \frac{1}{2}$ are given by, respectively:

$$CS^U_{x_0\leq\frac{1}{2}} = \int_0^{x_0}(V - p_A^U)dx + \int_{x_0}^{x_1^U}(V - p_A^U - s(x_1^U - x))dx + \int_{x_1^U}^{1}(V - p_B^U)dx, \text{ and} \tag{7a}$$

$$CS^U_{x_0\geq\frac{1}{2}} = \int_0^{x_1^U}(V - p_A^U)dx + \int_{x_1^U}^{x_0}(V - p_B^U - s(x_0 - x))dx + \int_{x_0}^{1}(V - p_B^U)dx; \tag{7b}$$

where p_A^U, p_B^U are given in Eq. (4a,b) and x_1^U is given in Eq. (5). With respect to, say, Eq (7a), the first term capture the surplus for those consumers staying with firm A, the middle term refers to those switching from firm B to firm A, and the last integral represents those staying with firm B. Solving these two equations yields the same solution:

$$CS^U = V - \frac{s(8{x_0}^2 - 8x_0 + 11)}{18}. \tag{8}$$

CS^U is decreasing in s, it has an inverted parabolic shape with maximum at $x_0 = \frac{1}{2}$, with value of $V - \frac{s}{2}$, and symmetric minima at $x_0 = 0{,}1$, with value of $V - \frac{s11}{18}$. That is to say, the existence of switching costs hurts consumers even at the stable middle point where there is no switching.[14]

1.2 History-based price discrimination

Under this configuration, firms can price discriminate by offering a 'poaching' price to rivals' customers, p_{ip}, alongside the price charged to attached (locked-in) customers p_{il}. Therefore, the objective functions for customers attached to firms A and B are given by, respectively:

[14] In other words, as switching costs approach zero the model reverts to homogeneous Bertrand competition where consumers can extract the entire surplus.

$$max\{V - p_{Al}, V - p_{Bp} - s(x_0 - x)\} \text{ and} \tag{9a}$$

$$max\{V - p_{Bl}, V - p_{Ap} - s(x - x_0)\}. \tag{9b}$$

The expressions for the cut-off points are given by, respectively:[15]

$$V - p_{Al} = V - p_{Bp} - s(x_0 - x) \rightarrow x = x_o - \frac{p_{Al}-p_{Bp}}{s} \equiv x_{1B}; \text{ and} \tag{10a}$$

$$V - p_{Bl} = V - p_{Ap} - s(x - x_0) \rightarrow x = x_o + \frac{p_{Bl}-p_{Ap}}{s} \equiv x_{1A}. \tag{10b}$$

Figure 5 illustrates this configuration.

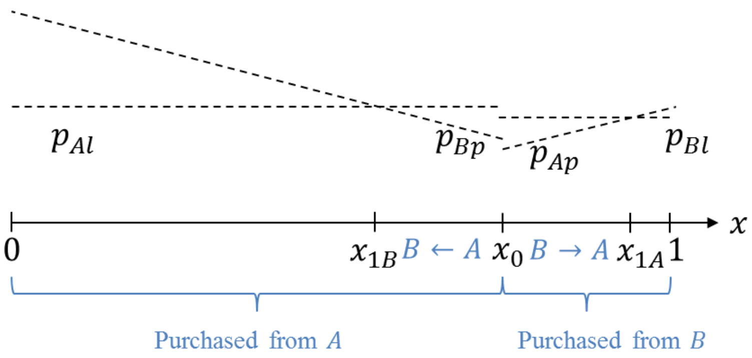

Fig. 5: spatial model of switching costs with history-based price discrimination.

The flat dotted lines correspond to the 'locked-in' prices. That is, there is no point in projecting the corresponding sloping lines over the rival's customer base as those prices would surely be dominated by the sloping lines corresponding to the 'poaching' prices offered by the same firm. The two cut-off points on the horizontal axis are identified by the two intersections between flat and sloping lines on each side of x_0. Therefore, under this configuration switching takes place in both directions.

Firms' profits under history-based price discrimination are given by:

$$\pi_A^H = p_{Al}\left(x_o - \frac{p_{Al}-p_{Bp}}{s}\right) + p_{Ap}\,\frac{p_{Bl}-p_{Ap}}{s} \text{ and} \tag{11a}$$

$$\pi_B^H = p_{Bl}\left(1 - x_o - \frac{p_{Bl}-p_{Ap}}{s}\right) + p_{Bp}\,\frac{p_{Al}-p_{Bp}}{s}. \tag{11b}$$

[15] There is no point in having a 'poaching' offer that doesn't deliver better value to rival's customers when compared to the option of sticking to the price for attached ('locked-in') customers. This is particularly the case when in practice there are even arbitrarily small 'menu costs' to issue and administer a new tariff. To note that we are ignoring the possibility that firms issue spurious tariffs just for the sake of confusing customers (i.e., price obfuscation via tariff proliferation). Moreover, it is straightforward to see how, in a static setting, both firms would always want to have a 'poaching' offer. In this respect, it is also worth noting that this is in contrast to traditional spatial models where the location identifies brand preferences, so that 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 (see Gehrig et al., 2012, Section 3).

Compared to the previous configuration, there is an additional term corresponding to the revenue from 'poaching', whereas the revenue extracted from retained customers includes a quantity deduction due to 'poaching' from the rival firm.

Solving firms' pairs of FOCs, $\frac{\partial \pi_i^H}{\partial p_{il}} = 0$ and $\frac{\partial \pi_i^H}{\partial p_{ip}} = 0$,[16] yields:

$$p_{Al}^H = \frac{2sx_o}{3} \text{ and } p_{Ap}^H = \frac{s(1-x_o)}{3}, \text{ and } p_{Bl}^H = \frac{2s(1-x_o)}{3} \text{ and } p_{Bp}^H = \frac{sx_o}{3}. \quad (12)$$

Whilst the price difference $p_{Al}^H - p_{Bp}^H = \frac{sx_0}{3}$ is increasing in both s and x_0 (with both prices increasing in x_0), the price difference $p_{Bl}^H - p_{Ap}^H = \frac{s(1-x_0)}{3}$ is increasing in s but decreasing in x_0 (with both prices decreasing in x_0). That is to say, 'poaching' prices are tied to rivals' 'locked-in' prices with a discount that is increasing in the degree of dominance of the rival firm. Figure 6 illustrates how equilibrium prices vary with respect to x_0:

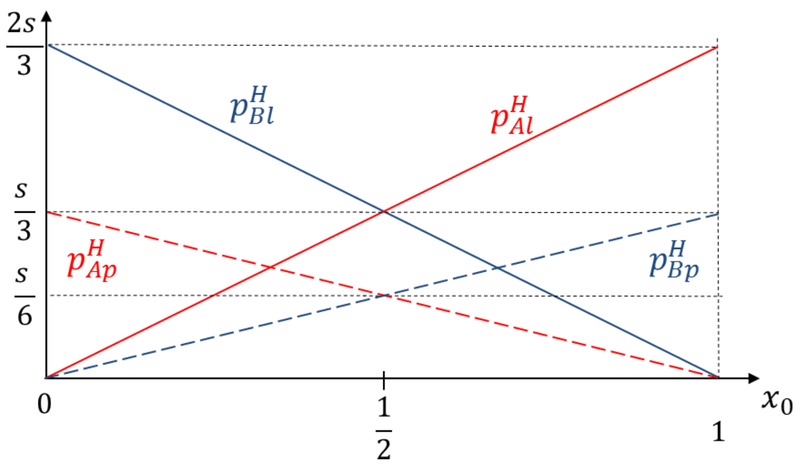

Fig. 6: equilibrium prices under history-based price discrimination.

It is interesting to observe that these equilibrium prices are always lower than those under the previous configuration, but for those available to a customer attached to a monopolistic firm. For example, at $x_0 = 0$, p_{Bl}^H and p_{Ap}^H are the same as, respectively, p_B^U and p_A^U, for $0 < x_0 < 1$ consumers benefit from lower prices from both firms. That is to say, the common use of history-based price discrimination is not only beneficial to "front-book" customers, but also "back-book" ones. This is in contrast to the often heard argument that the use of history-based price discrimination might have a distributional implications whereby "front-book" customers are subsidised by "back-book" ones.[17]

[16] It is straightforward to verify that the corresponding second order conditions are satisfied.
[17] We think that this is thanks to the smooth distribution of heterogeneous switching costs. We speculate that the result would differ if customers were split between 'shoppers', with a low switching costs, and 'non-shopper', who do not switch at all. This partition is of course reminiscent of the 'tourists vs. locals' predominant in the search cost literature and more recently in much of the literature on behavioural economics, ie, with the partition between 'naïves and sophisticates'. Under such a scenario, locked-in

The equilibrium cut-off points are given by:

$$x_{1A}^H = \frac{2x_0+1}{3} \text{ and } x_{1B}^H = \frac{2x_0}{3}. \tag{13}$$

As under uniform pricing, these expressions do not depend on the switching cost parameter s. The total amount of switching, which is given by the difference $x_{1A}^H - x_{1B}^H = \frac{1}{3}$ is constant and is distributed asymmetrically according to the expressions $x_{1A}^H - x_0 = \frac{1-x_0}{3}$ and $x_0 - x_{1B}^H = \frac{x_0}{3}$. Figure 7 below illustrates this.

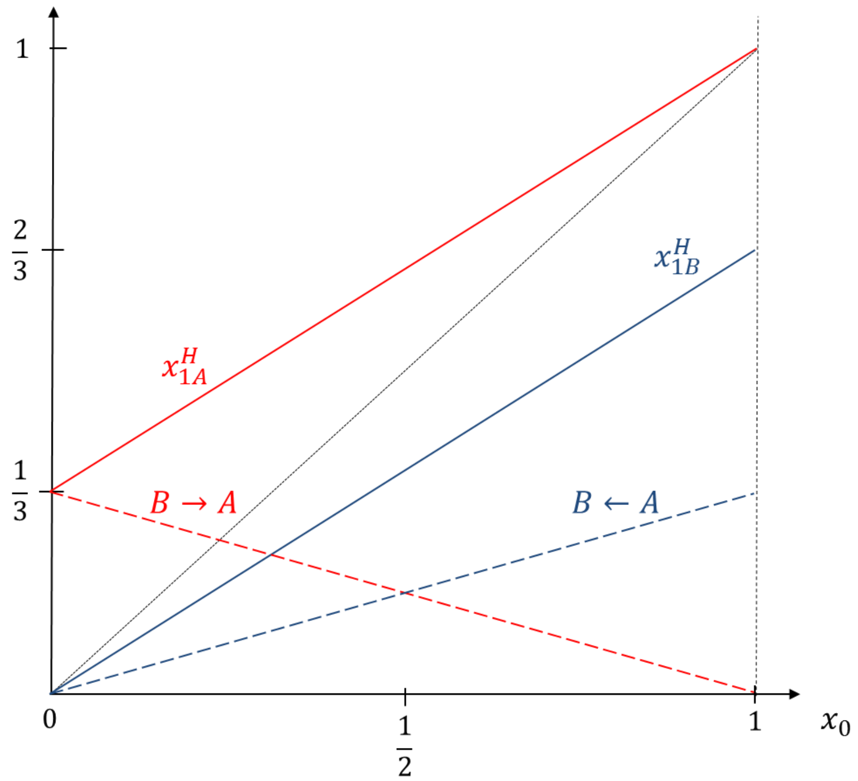

Fig. 7: equilibrium cut-off quantities and extent of switching under history-based price discrimination.

The differences with the 45-degree dotted line represent the volume of external switching which are also depicted with the corresponding coloured dotted lines. Similar to the previous configuration, $x_0 = \frac{1}{2}$ is a stable starting point. However, in contrast to the case under uniform pricing, switching occurs in both directions.[18]

Equilibrium profits are given by:

$$\pi_A^H = \frac{s(5{x_0}^2 - 2x_0 + 1)}{9} = \frac{{p_{Al}^H}^2 + {p_{Ap}^H}^2}{s} \text{ and} \tag{14a}$$

prices would arguably increase compared to uniform prices, as the rival's poaching price would not exert any constraint whatsoever.

[18] It is also interesting to note that the magnitude of the adjustment towards the middle point, which is given by the expression $x_0 + (x_{1A}^H - x_0) - (x_0 - x_{1B}^H) = \frac{x_0+1}{3}$, is the same as under uniform pricing.

$$\pi_B^H = \frac{s(5{x_0}^2 - 8x_0 + 4)}{9} = \frac{{p_{Bl}^H}^2 + {p_{Bp}^H}^2}{s}. \tag{14b}$$

Profits have same values at the extreme of the interval $x_0 \in [0,1]$ as under uniform pricing, but with internal minima at, respectively, $x_0 = \frac{1}{5}$ and $x_0 = \frac{4}{5}$. These can be thought of as growth traps in the early expansion phases (ie, once the smaller firm reaches a 20% market share), where the larger firm starts to take notice and adjust its 'lock-in' price defensively, whilst the small firm starts to feel the pressure from the incursion of its rival.

Graphically, with respect to x_0 (and by setting $s = 1$):

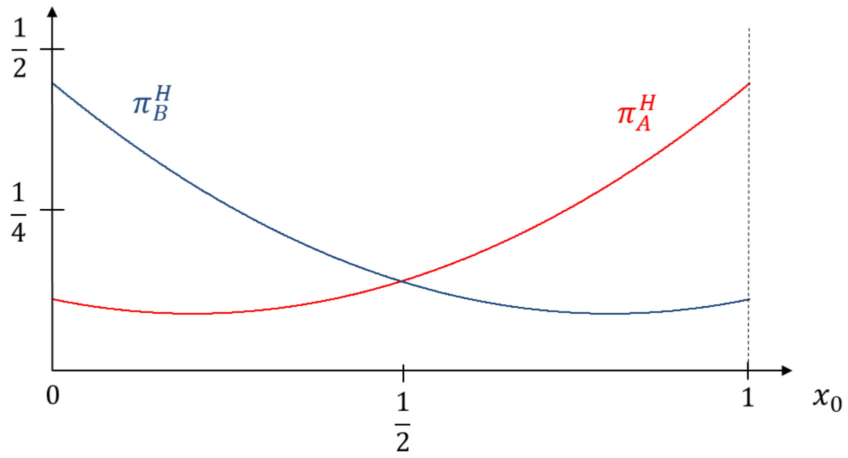

Fig. 8: equilibrium profits under history-based price discrimination.

Therefore, firms' profits are always lower than under uniform pricing. In particular, the difference $\pi_i^U - \pi_i^H$ has an inverted-U relationship with maximum at the middle point.[19]

Finally, the expression for consumer surpluses is given by:

$$CS^H = \int_0^{x_{1B}^H} (V - p_{Al}^H)dx + \int_{x_{1B}^H}^{x_0} (V - p_{Bp}^H - s(x_0 - x))dx + \int_{x_0}^{x_{1A}^H} (V - p_{Ap}^H - s(x_{1A}^H - x))dx + \int_{x_{1A}^H}^{1} (V - p_{Bl}^H)dx, \tag{15}$$

where p_{il}^H, p_{ip}^H are given in Eq. (12) and x_{1i}^H is given in Eq. (13). The first and fourth terms refer to consumers who stay with firm A and B and the second and third ones to those who switch to firm B and A respectively.

$$CS^H = V - \frac{s(22{x_0}^2 - 22x_0 + 11)}{18}. \tag{16}$$

[19] This is of course in line with the finding 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'. See Armstrong (2006, Section 5).

Similarly to the case under uniform pricing, CS^H is decreasing in s, it has an inverted symmetric parabolic shape, with maximum at $x_0 = \frac{1}{2}$, but higher value of $V - \frac{11s}{36}$, and the same symmetric minima at $x_0 = 0{,}1$, with value of $V - \frac{s11}{18}$. That is to say, the existence of switching costs hurts consumers, but less than under uniform pricing, thanks to the intensified pricing rivalry under history-based price discrimination. This is so notwithstanding the fact that the volume of costly switching, even at the stable middle point, tends to the higher than under uniform pricing. The observation that the common use of history-based price discrimination hurts firms' profitability prompts an investigation into whether firms have a unilateral incentive to start adopting it. This is what we turn to in the next section.

1.2.1 Unilateral incentives to use history-based price discrimination

To understand the circumstances under which a firm would have the incentive to unilaterally offer a 'poaching' price it is necessary to compute the profit of the firm in question, say firm B, when the rival firm does not follow suit. Accordingly, the objective functions for customers attached to firms A and B are given by, respectively:

$$max\{V - p_{Au}, V - p_{Bp} - s(x_0 - x)\} \text{ and} \tag{17a}$$

$$max\{V - p_{Bl}, V - p_{Au} - s(x - x_0)\}. \tag{17b}$$

Figure 9 below illustrates this configuration.

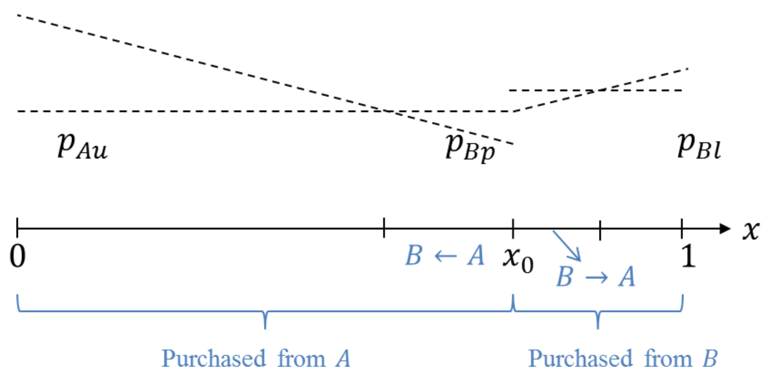

Fig. 9: spatial model of switching costs with uniform pricing and history-based price discrimination.

The dotted line corresponding to the uniform price charged by firm A has both a flat and a sloping segment. The former is intersected by the sloping line corresponding to the undercutting 'poaching' price introduced by firm B, and the latter intersects the flat line corresponding to the 'locked-in' price charged by firm B. Hence, switching takes place in both directions.

Firm's profits are given by:

$$\pi_A^{U/H} = p_{Au}\left(x_o - \frac{p_{Au} - p_{Bp}}{s}\right) + p_{Au}\,\frac{p_{Bl} - p_{Au}}{s} \text{ and} \tag{18a}$$

$$\pi_B^{H/U} = p_{Bl}\left(1 - x_o - \frac{p_{Bl}-p_{Au}}{s}\right) + p_{Bp}\,\frac{p_{Au}-p_{Bp}}{s}. \tag{18b}$$

Whilst the expression for firm B's profit in Eq. (18b) is very similar to the one in Eq. (11b) under common use of history-based price discrimination, the expression for firm A's profit differs from the one in Eq. (3b) under common use of uniform pricing in that the uniform price undercuts the rival's 'locked-in' price and is undercut by the rival's 'poaching' one. In other words, the firm that unilaterally adopts history-based price discrimination tolerates some 'poaching' from the rival firm in order to maximise the revenue extracted from its retained customers with a high 'locked-in' price.

Solving the system of FOCs, $\frac{\partial \pi_A^{U/H}}{\partial p_{Au}} = 0$, $\frac{\partial \pi_B^{H/U}}{\partial p_{Bl}} = 0$ and $\frac{\partial \pi_B^{H/U}}{\partial p_{Bp}} = 0$ yields:[20]

$$p_{Au}^{U/H} = \frac{s(x_o+1)}{6},\; p_{Bl}^{H/U} = \frac{s(7-5x_o)}{12} \text{ and } p_{Bp}^{H/U} = \frac{s(x_o+1)}{12}. \tag{19}$$

Firms' equilibrium profits are given by:

$$\pi_A^{U/H} = \frac{s(x_o+1)^2}{18} = \frac{2{p_{Au}^{U/H}}^2}{s} \text{ and} \tag{20a}$$

$$\pi_B^{H/U} = \frac{s(13{x_0}^2-36x_0+25)}{72} = \frac{{p_{Bl}^{H/U}}^2+{p_{Bp}^{H/U}}^2}{s}. \tag{20b}$$

Figure 10 below compares $\pi_B^{H/U}$ in Eq. (20b) against firm B's profits under common use of uniform pricing as in Eq. (6b) (with $s = 1$). It is straightforward to see that firm B's decision to (unilaterally) start using history-based price discrimination would tend to hurt its own profitability.

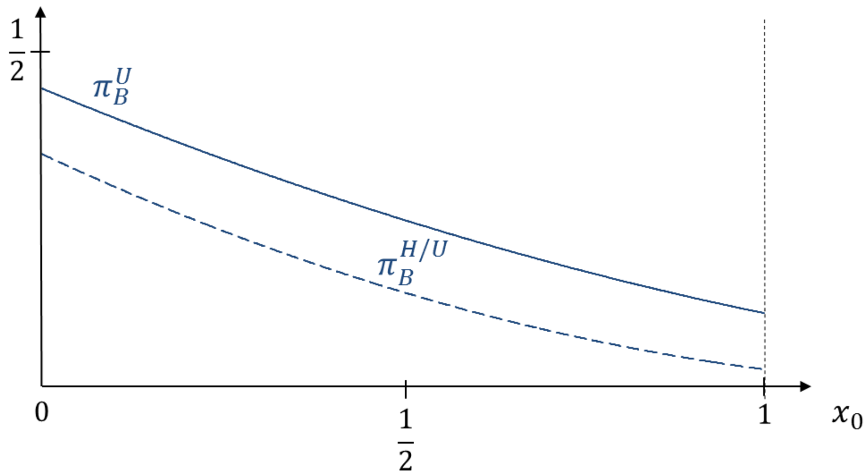

Fig. 10: comparison of firm B's equilibrium profits under symmetric and asymmetric regimes.

Therefore, in contrast to previous result in Thisse and Vives (1988), which was based on the classic Hotelling framework, firms do not face a Prisoners Dilemma whereby,

[20] It is straightforward to verify that the corresponding second order conditions are satisfied.

whilst they would be better off under symmetric uniform pricing, the strategy to adopt history-based price discrimination dominates because the resulting increase in profit is large (and the loss from being unilaterally exposed to a rival using it is large too).[21] The underlying intuition for our contrasting result is that the presence of brand loyalty under the Hotelling framework partly insulates the firm that moves unilaterally from the fact that the rival will have to lower its uniform price which in turn will exert downward pressure on the 'locked-in' price that can be charged by the firm in question. Without that extra source of market power, our results show that profits fall when firms unilaterally poach rival's customers.

It could be argued, however, that the unilateral adoption of history-based price discrimination could be motivated instead by an attempt to deter (foreclose) a new entrant (small firm). To investigate this line of argument, Figure 11 below compares firm A's equilibrium profit when it is unilaterally exposed to a rival adopting history-based price discrimination against its profits under the common use of uniform pricing and history-based price discrimination.

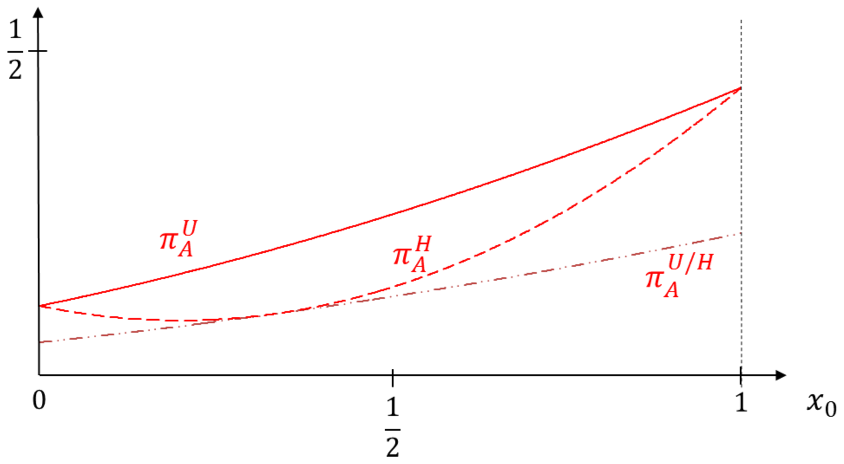

Fig. 11: comparison of firm A's equilibrium profits under symmetric and asymmetric regimes.

Whilst firm A's profit falls when it is exposed to a rival that unilaterally adopts history-based price discrimination, a clear defensive response to that threat would be to reciprocate its use, in particular when the inherited market shares are very asymmetric. This is show by the fact that the profit curve labelled π_A^H restores some of the lost profit given by the difference between π_A^U and $\pi_A^{U/H}$, and to a larger extent the more skewed are market shares. Therefore, the larger firm could reason that it would be better to adopt history-based price discrimination under the belief that the smaller rival might opt for doing so for its own defensive purposes. Indeed, for the larger firm to err on the side of caution is a particularly compelling proposition in light of the fact that the (absolute) profit fall from being exposed to a rival who unilaterally adopts history-based price discrimination is very large, as shown in Figure 11 above for values of x_o close to 1.

[21] See also discussion in Stole (2007: 2242).

To conclude, the most plausible explanation for the symmetric adoption of history-based price discrimination is neither the Prisoners Dilemma nor anti-competitive foreclosure, but the mutual reaction to avoid the fall in profits that result from being unilaterally exposed to history-based price discrimination.

1.3 History-based price discrimination with 'leakage'

As discussed in the introduction, the persistent unresponsiveness of sticky 'disengaged' customers has prompted competition regulators to seek remedies aimed at assisting them. A peculiar approach is to facilitate 'internal' switching within the same service provider by imposing a duty on firms to assist their own customers in upgrading onto a the best alternative tariff available.[22] To model this, as under the previous common configuration, firms can price discriminate by offering a 'poaching' price to rivals' customers, p_{ip}. However, there is 'leakage', in the sense that firms cannot prevent their own customers from transferring onto the same 'poaching' offer when this is sufficiently lower than the 'locked-in' price offered to retained customers, p_{il}. Therefore, the objective functions for customers attached to firms A and B are given by, respectively:

$$max\{V - p_{Al}, V - p_{Ap} - \alpha s(x_0 - x), V - p_{Bp} - s(x_0 - x)\} \text{ and} \tag{21a}$$

$$max\{V - p_{Bl}, V - p_{Bp} - \alpha s(x - x_0), V - p_{Ap} - s(x - x_0)\}, \tag{21b}$$

where $\alpha \in (0,1)$ indicates that the cost of switching internally to the ' poaching' offer from the current firm is typically lower than the cost of switching externally to the 'poaching' offer from the other firm.[23] Accordingly, there are, in principle, three pairs of cut-off points. Specifically, for customers attached to firm A:

$$V - p_{Al} = V - p_{Ap} - \alpha s(x_0 - x) \rightarrow x = x_o - \frac{p_{Al} - p_{Ap}}{\alpha s} \equiv x_{1A(int)} \; if \; p_{Al} \geq p_{Ap}, \text{ and}$$

$$V - p_{Al} = V - p_{Bp} - s(x_0 - x) \rightarrow x = x_o - \frac{p_{Al} - p_{Bp}}{s} \; if \; p_{Al} \geq p_{Bp} \text{ or}$$

$$V - p_{Ap} - \alpha s(x_0 - x) = V - p_{Bp} - s(x_0 - x) \rightarrow x = x_o - \frac{p_{Ap} - p_{Bp}}{s(1-\alpha)} \; if \; p_{Ap} \geq p_{Bp}, \text{ with}$$

$$x_{1B} \equiv \max\left(x_o - \frac{p_{Al} - p_{Bp}}{s} \; if \; p_{Al} \geq p_{Bp}, x_o - \frac{p_{Ap} - p_{Bp}}{s(1-\alpha)} \; if \; p_{Ap} \geq p_{Bp}\right). \tag{22}$$

Similarly, for customers attached to firm B:

$$V - p_{Bl} = V - p_{Bp} - \alpha s(x - x_0) \rightarrow x = x_o + \frac{p_{Bl} - p_{Bp}}{\alpha s} \equiv x_{1B(int)} \; if \; p_{Bp} \geq p_{Bl}, \text{ and}$$

$$V - p_{Bl} = V - p_{Ap} - s(x - x_0) \rightarrow x = x_o + \frac{p_{Bl} - p_{Ap}}{s} \; if \; p_{Bl} \geq p_{Ap} \text{ or}$$

[22] For example, in the context of a market study on banks' provision of cash saving accounts, the UK Financial Conduct Authority considered the imposition of a 'return switching form' remedy, a very simple 'tear-off' form and pre-paid envelope enabling a customer to switch to a better paying account offered by their existing firm more easily (FCA2016b, para. 1.7).

[23] This can be because the 'poaching' offer by the current firm is more salient and/or there are lower (perceived) 'hassle' costs involved in switching internally whilst staying with the same firm.

$$V - p_{Bp} - \alpha s(x - x_0) = V - p_{Ap} - s(x - x_0) \rightarrow x = x_o + \frac{p_{Bp} - p_{Ap}}{s(1-\alpha)} \ if \ p_{Bp} \geq p_{Ap}, \text{ with}$$

$$x_{1A} \equiv \min\left(x_o + \frac{p_{Bl} - p_{Ap}}{s} \ if \ p_{Bl} \geq p_{Ap}, x_o + \frac{p_{Bp} - p_{Ap}}{s(1-\alpha)} if \ p_{Bp} \geq p_{Ap}\right). \qquad (23)$$

The expression for x_{1i} indicates that customers attached to firm i take into consideration the option to switch internally to p_{ip} only to the extent that it delivers better value than sticking to p_{il} when compared to switching to the other firm's 'poaching' offer p_{jp}, with $j \neq i$. As shown formally later on, this result would always be the case as long as switching at all is a valuable option, as opposed to sticking to the 'locked-in' price.

Specifically, under 'leakage' to the extent that the rival's 'poaching' price is lower than the current 'locked-in' price, the 'poaching' price offered by the current firm will also be lower than the current 'locked-in' price, although above the rival's 'poaching' price. This is because, on the one hand, the firm in question is using the 'poaching' price as a defensive tool, that is, primarily aimed at limiting the extent of external switching by retaining some of its customers with relatively low switching costs, rather than enticing rival' s customers to switch. On the other hand, in doing so, the firm in question is also keen to limit the extent of internal switching, which cannibalises the revenue extracted from retained 'locked-in' customers.

Intuitively, therefore, the firm with the larger market share would set the 'poaching' price defensively, whereas the smaller firm would set its own 'poaching' price offensively, that is, aimed at triggering external switching. However, in doing so, the smaller firm will be constrained by the cannibalisation of its own customer base, which, in turn, limits its ability to set a high 'locked-in' price. In a sense, 'leakage' changes the strategic framework from one where firms exhibit 'best-response asymmetry', whereby firms hold opposing views as to which category of consumer should be targeted, to the opposite setting with 'best-response symmetry', whereby firms agree on who are the consumers facing higher switching costs. However, this change in the strategic framework is partly offset by the fact that it is comparatively more convenient to switch internally.

It is worth noting that where $x_{1B} = x_o - \frac{p_{Al} - p_{Bp}}{s}$ ($x_{1A} = x_o + \frac{p_{Bl} - p_{Ap}}{s}$) it follows that $x_{1A(int)} > x_{1B}$ ($x_{1B(int)} < x_{1A}$), that is, customers attached to firm A (B) will simply ignore the option to switch internally altogether. Where switching internally is dominated by switching externally, the 'poaching' offer of the firm in question also fails to poach rival's customers. Therefore, similarly to the previous configuration, there is no point in having a 'poaching' offer that doesn't deliver better value for at least some attached customers when compared to the option of switching externally.

In contrast to the previous configuration, but similarly to the configuration under uniform pricing, switching occurs only in one direction. In particular, as shown later on, switching takes place from the larger firm to the smaller one. However, both firms are subject to internal switching: for the larger one this is in order to retain customers with relatively low switching costs, whereas for the smaller one this is seen as a constraint on the exploitation of ‘locked-in’ customers.

Figure 12 below illustrates this setting:

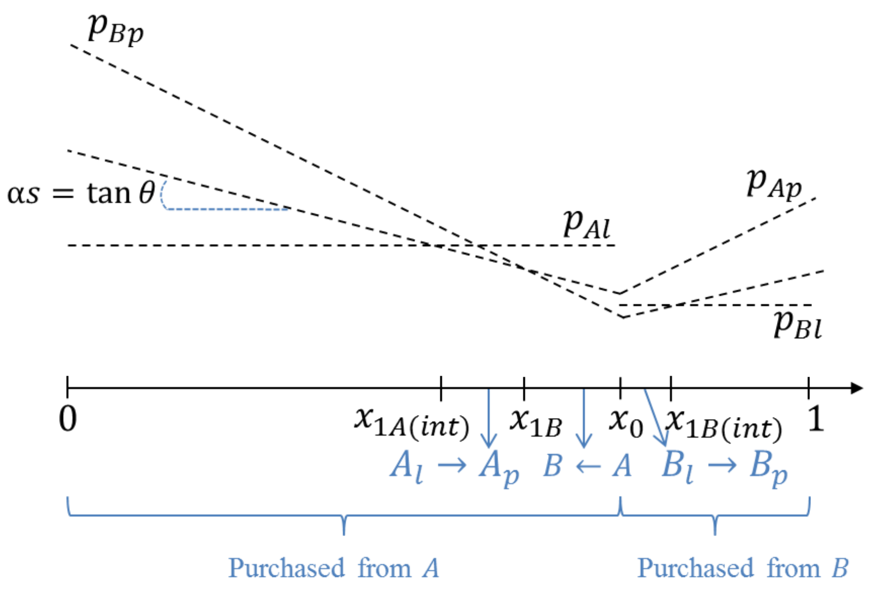

Fig. 12: spatial model of switching costs with history-based price discrimination, but with ‘leakage’.

Whilst the flat lines corresponding to firms’ ‘locked-in’ price the same as in the previous configuration, the sloping lines corresponding to the ‘poaching’ prices differ in that there is an additional segment projecting in opposite direction over the customer base of the firm in question. Furthermore, the slope of this additional segment is lower than the slope of the poaching price’s schedule projected over the customer base of the rival firm, that is, thanks to the internal switching parameter α. There are three relevant intersections. First, there is the one between the shallower sloping line of the (defensive) ‘poaching’ price of firm A and the flat line corresponding to the ‘locked-in’ price charged by the same firm. This intersection identifies on the horizontal axis firm A’s threshold for internal switching labelled $x_{1A(int)}$. Second, there is the intersection between the same shallower sloping line and the steeper sloping line corresponding to the ‘poaching’ price offered by firm B which identifies the only threshold for external switching labelled x_{1B}. Finally, firm B’s own internal switching threshold labelled $x_{1B(int)}$ is identified by the intersection with the shallower sloping line corresponding to its own ‘poaching’ price and the flat line corresponding to its ‘locked-in’ price, whereas the steeper sloping line corresponding to firm A’s ‘poaching’ price doesn’t intersect that flat line at all.

Firms’ profits under history-based price discrimination, but with ‘leakage’, are given by:

$$\pi_A^L = p_{Al}\left(x_o - \frac{p_{Al}-p_{Ap}}{\alpha s}\right) + p_{Ap}\left(\frac{p_{Al}-p_{Ap}}{\alpha s} - \frac{p_{Ap}-p_{Bp}}{s(1-\alpha)}\right) \text{ and} \tag{24a}$$

$$\pi_B^L = p_{Bl}\left(1 - x_o - \frac{p_{Bl}-p_{Bp}}{\alpha s}\right) + p_{Bp}\left(\frac{p_{Bl}-p_{Bp}}{\alpha s} - \frac{p_{Bp}-p_{Ap}}{s(1-\alpha)}\right). \tag{24b}$$

The quantity expression within brackets in the first profit term corresponding to the 'locked-in' price includes a deduction due to internal switching for both firms, whereas the quantity expression within brackets in the second term corresponding to the 'poaching' price is made by the volume of internal switching plus or minus external switching depending on which firm is using this price defensively. As shown below formally, this is always the larger firm.

Solving firms' pairs of FOCs, $\frac{\partial \pi_i^L}{\partial p_{il}} = 0$ and $\frac{\partial \pi_i^L}{\partial p_{ip}} = 0$,[24] yields:

$$p_{Al}^L = \frac{\alpha s x_o}{2} + \frac{s(1-\alpha)(x_o+1)}{3} \text{ and } p_{Ap}^L = \frac{s(1-\alpha)(x_o+1)}{3}, \text{ and } p_{Bl}^L = \frac{\alpha s(1-x_o)}{2} + \frac{s(1-\alpha)(2-x_o)}{3} \text{ and}$$

$$p_{Bp}^L = \frac{s(1-\alpha)(2-x_o)}{3}. \tag{25}$$

The main difference with the previous configuration is that with 'leakage' 'poaching' prices are no longer tied to rivals' 'locked-in' prices, but are instead tied to the 'locked-in' price offered by the same firm, with a discount equal to $\frac{\alpha s x_o}{2}$ and $\frac{\alpha s(1-x_o)}{2}$ for firm A and B, respectively, that is growing in the inherited market share of the firm in question. Intuitively, from the perspective of the larger firm, 'leakage' makes 'poaching' prices defensive in nature; whereas, from the perspective of the smaller firm, 'leakage' constitute a constraint on the ability to exploit attached customers by setting a high 'locked-in' price. The magnitude of these discounts increases with α, so that the effectiveness of the retention strategy of the large firm fades away as the comparative convenience of internal switching shrinks. Accordingly, as pricing rivalry increases with α, all prices fall.[25] Figures 13a and 13b below illustrate this for $\alpha = \frac{1}{4}, \frac{3}{4}$.

[24] It is straightforward to verify that the corresponding second order conditions are satisfied.

[25] It is straightforward to verify that $\frac{\partial p_{ip}^L}{\partial \alpha} < 0$. The expressions for $\frac{\partial p_{il}^L}{\partial \alpha}$ are respectively $\frac{\partial p_{Al}^L}{\partial \alpha} = \frac{s(x_0-2)}{6}$ and $\frac{\partial p_{Bl}^L}{\partial \alpha} = -\frac{s(x_0+1)}{6}$, which are also both negative.

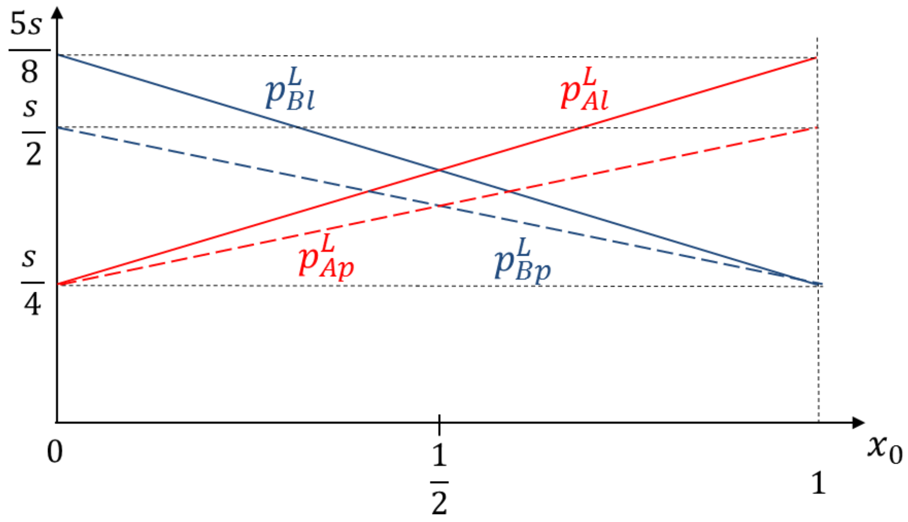

Fig. 13a: equilibrium prices under history-based price discrimination, but with 'leakage', for $\alpha = \frac{1}{4}$.

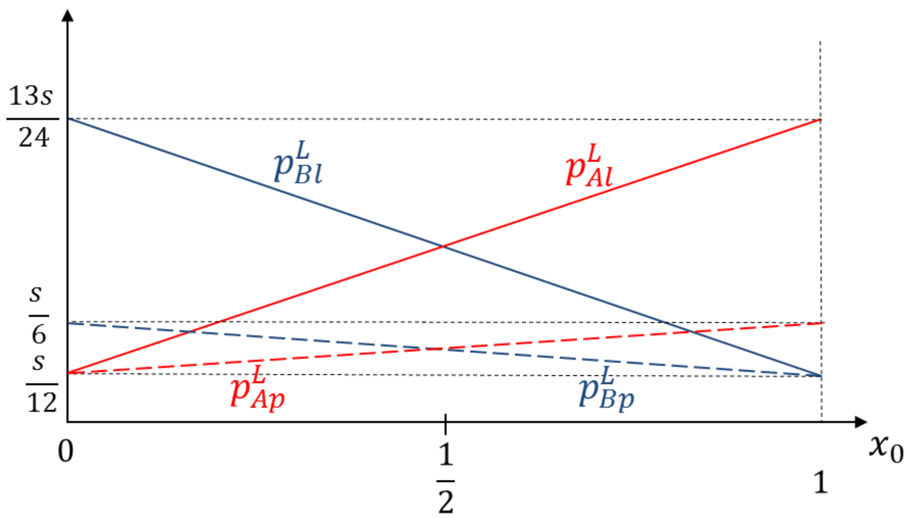

Fig. 13b: equilibrium prices under history-based price discrimination, but with 'leakage', for $\alpha = \frac{3}{4}$.

It is interesting to observe that for very low values of α (i.e., internal switching is comparatively a lot more convenient), firms' prices converge towards those under uniform pricing, meaning that for very low values of α the imposition of 'leakage' neutralises the use of history-based price discrimination when compared to the basic case under uniform pricing. It is also interesting to note that, because under 'leakage' the 'poaching' price of the larger firm is no longer aimed at triggering external switching, the smaller firm can set higher 'locked-in' prices, compared to the previous configuration, when its inherited market share is very small. That is to say, the imposition of 'leakage' helps the smaller firm extract rents from retained customers, thanks to the fact that the larger firm is more concerned about retaining its own.

The equilibrium cut-off points are given by:

$$x^L_{1A(int)} = \frac{x_0}{2}, x^L_{1B(int)} = \frac{x_0+1}{2} \text{ and } x^L_{1A_{(x_0 \geq \frac{1}{2})}} = x^L_{1B_{(x_0 \leq \frac{1}{2})}} = \frac{x_0+1}{3} \equiv x^L_1. \qquad (26)$$

Similarly to the previous configurations, the amount of switching, either internal or external, does not depend on either of the switching parameters, s and α. The fact that the expression for x^L_{1A} (with $x_0 \geq \frac{1}{2}$) is the same as the one for x^L_{1B} (with $x_0 \leq \frac{1}{2}$) confirms that, similar to the case under uniform pricing, external switching occurs only in one direction, from the larger firm to the smaller one, with no external switching taking place when firms inherit symmetric market share (i.e., $x_0 = \frac{1}{2}$). This in turn entails that, similarly to the previous configurations, the middle point is a stable solution. Nevertheless, there is always internal switching which is increasing the larger is the inherited market share.

Figures 14 and 15 below illustrate these features.

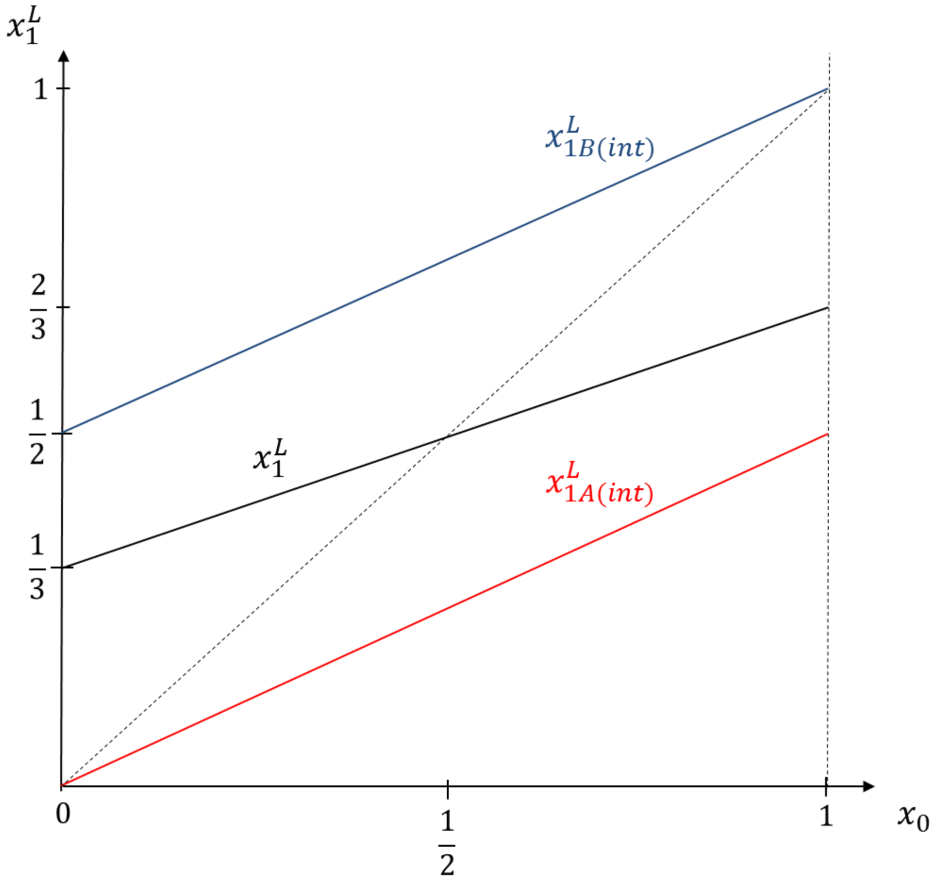

Fig. 14: equilibrium cut-off quantities under history-based price discrimination, but with 'leakage'.

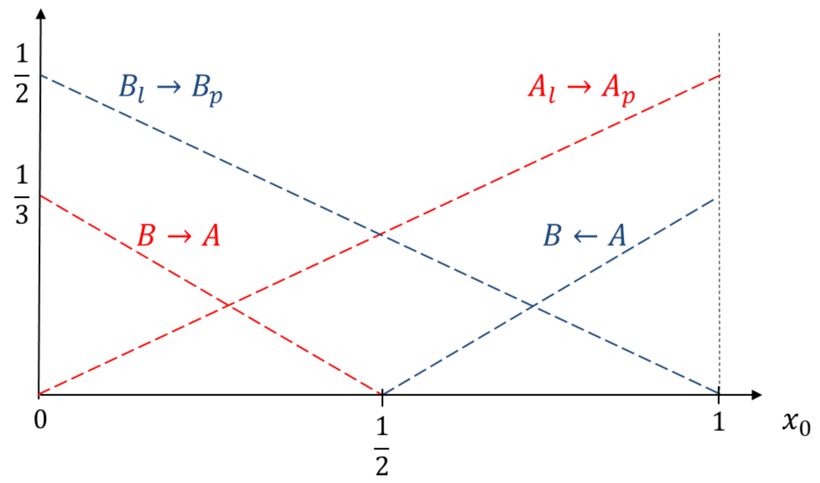

Fig. 15: extent of (internal and external) switching under history-based price discrimination, but with 'leakage'.

Equilibrium profits are given by:

$$\pi_A^L = \frac{\alpha s x_0^2}{4} + \frac{s(1-\alpha)(x_0+1)^2}{9} \text{ and } \pi_B^L = \frac{\alpha s(1-x_0)^2}{4} + \frac{s(1-\alpha)(2-x_0)^2}{9}. \tag{27}$$

As shown by the expressions for equilibrium prices, for very low values of α (i.e., internal switching is comparatively a lot more convenient) firms' profits approach those under uniform pricing, which is beneficial to firms. Intuitively, firms anticipate that all attached customers will want to switch internally rather than stay on the 'locked-in' price. At the same time, firms enjoy a comparative advantage in retaining attached customers. Therefore, they are induced to soften pricing rivalry in terms of both 'locked-in' and 'poaching' prices. As α increases (i.e., external switching becomes comparatively similarly convenient) profits fall. This is particularly so at the minima located at the two extremes of the line, given that the smaller firm is purely intent on 'poaching', that is, not caring about the fact that a low 'poaching' price will constrain the ability to set a high 'locked-in' price to extract rents from attached customers

Figures 16a and 16b below illustrate these features for $\alpha = \frac{1}{4}, \frac{3}{4}$ (and by setting $s = 1$).

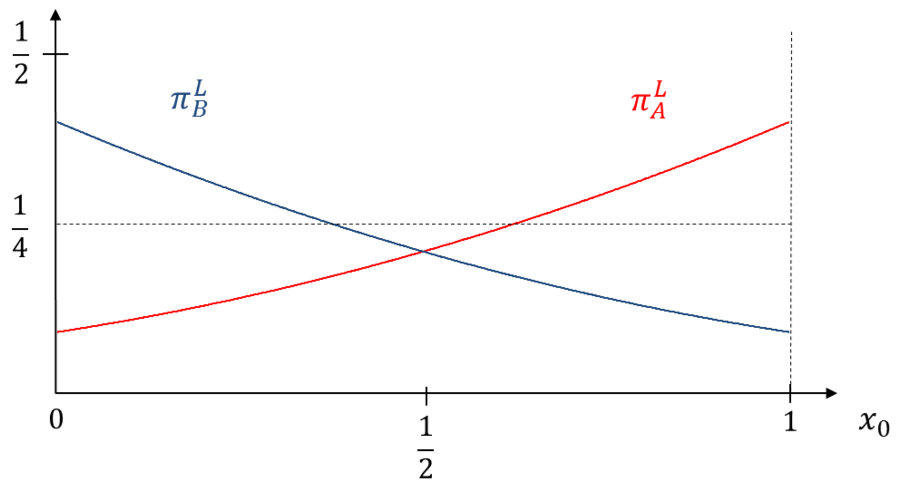

Fig. 16a: equilibrium profits under history-based price discrimination, but with 'leakage', for $\alpha = \frac{1}{4}$.

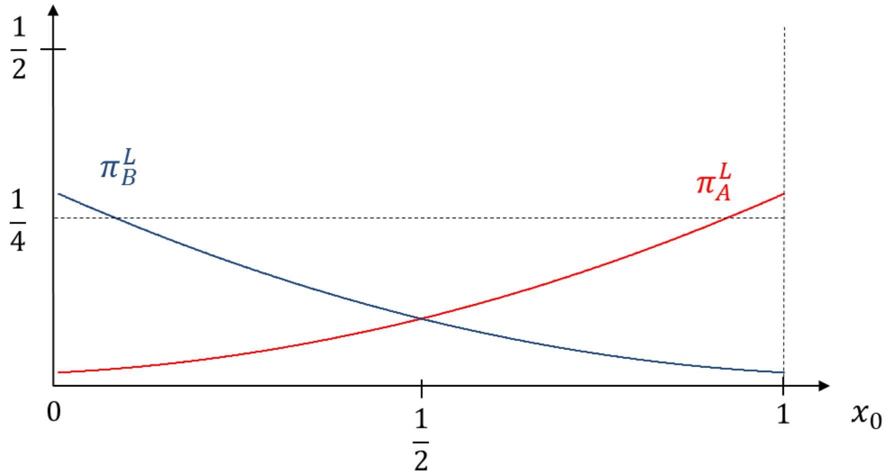

Fig. 16b: equilibrium profits under history-based price discrimination, but with 'leakage', for $\alpha = \frac{3}{4}$.

In light of the fact that, similarly to the configuration under uniform pricing, external switching only occurs from the larger to the smaller firm, the expressions for consumer welfare when $x_0 \leq \frac{1}{2}$ and $x_0 \geq \frac{1}{2}$ are given by, respectively:

$$CS^L_{x_0 \leq \frac{1}{2}} = \int_0^{x^L_{1A(int)}} (V - p^L_{Al})dx + \int_{x^L_{1A(int)}}^{x_0} (V - p^L_{Ap} - \alpha s(x_0 - x))dx + \int_{x_0}^{x_1^L} (V - p^L_{Ap} - s(x - x_0))dx + \int_{x_1^L}^{x^L_{1B(int)}} (V - p^L_{Bp} - \alpha s(x - x_0))dx + \int_{x^L_{1B(int)}}^{1} (V - p^L_{Bl})dx, \text{ and} \tag{28a}$$

$$CS^L_{x_0 \geq \frac{1}{2}} = \int_0^{x^L_{1A(int)}} (V - p^L_{Al})dx + \int_{x^L_{1A(int)}}^{x_1^L} (V - p^L_{Ap} - \alpha s(x_0 - x))dx + \int_{x_1^L}^{x_0} (V - p^L_{Bp} - s(x_0 - x))dx + \int_{x_0}^{x^L_{1B(int)}} (V - p^L_{Bp} - \alpha s(x - x_0))dx + \int_{x^L_{1B(int)}}^{1} (V - p^L_{Bl})dx; \tag{28b}$$

where p^L_{il}, p^L_{ip} are given in Eq. (25) and $x^L_{1i(int)}$ and x^L_1 are given in Eq. (26). With respect to, say, Eq. (28a), the first and last term refer to consumers who do not switch even internally. The second and penultimate terms refers to internal switching and the third one to external switching.

Solving these two equations yields the same solution:

$$CS^L = V - \frac{s(8{x_0}^2 - 8x_0 + 11)}{18} - \frac{\alpha s(22{x_0}^2 - 22x_0 - 17)}{72}. \tag{29}$$

Similarly to previous configurations, CS^L is decreasing in s and has symmetric inverted parabolic shape, with maximum at $x_0 = \frac{1}{2}$. The first two terms on the right hand side in Eq. 29 are equal to the expression for CS^U, entailing that for very low values of α (i.e., internal switching is comparatively a lot more convenient) the presence of 'leakage' reduces the extent to which consumers benefit from the use of history-based price discrimination, when compared to the basic case under uniform pricing. However, as α increases consumer surplus increases, thanks to the intensification of pricing rivalry. The following section compares firms' profits and consumer surpluses under the three pricing regimes.

2 Comparison and discussion

This section compares the outcomes under the three common pricing regimes analysed above. First, figures 17a and 17b compare firm A's profits under the three pricing regimes,[26] for $\alpha = \frac{1}{4}, \frac{3}{4}$ (and by setting $s = 1$).

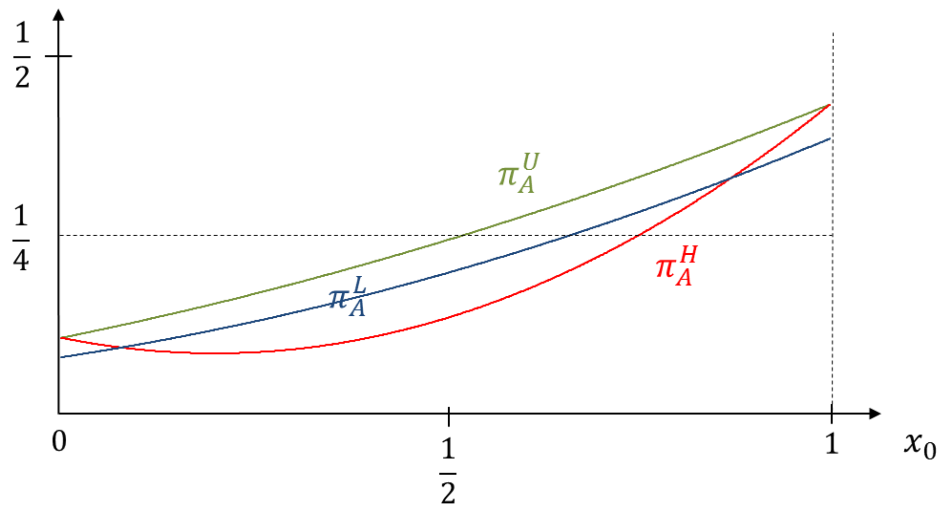

Fig. 17a: comparison of equilibrium profits under the three pricing regimes, for $\alpha = \frac{1}{4}$.

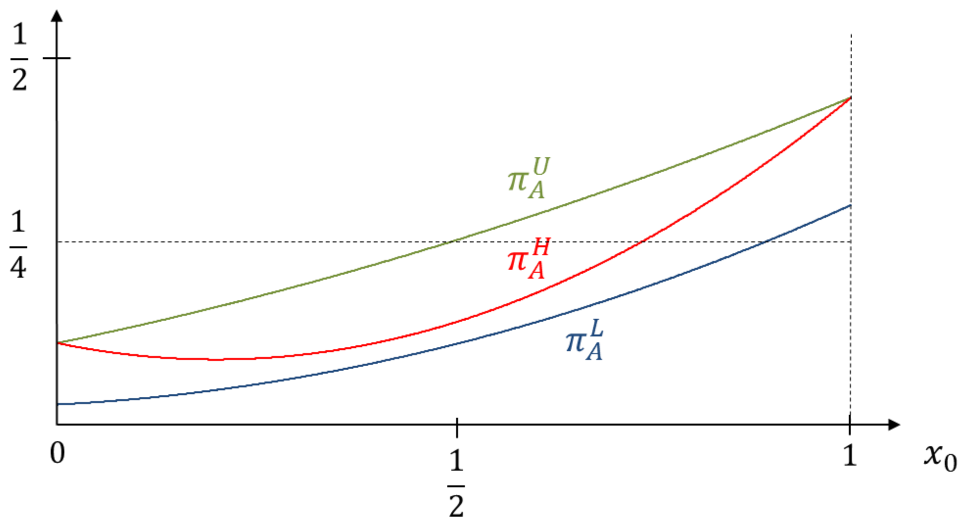

Fig. 17b: comparison of equilibrium profits under the three pricing regimes, for $\alpha = \frac{3}{4}$.

[26] Firm B's profits, which are specular to firm A's, are not depicted for ease of representation.

For sufficiently low values of α (i.e., internal switching is comparatively more convenient), firms' profits under history-based price discrimination are higher when there is 'leakage', but for highly asymmetric inherited market shares (Figure 17a).[27] As explained in the previous section, the imposition of 'leakage' neutralises the toughening effect that the use of history-based price discrimination has on pricing rivalry, thanks to the fact that the larger firm can use the 'poaching' price as a defensive tool.[28] However, as external switching catches up in terms of comparative convenience, pricing rivalry aimed primarily at retaining customers intensifies and is stronger than under history-based price discrimination without 'leakage'. Figure 18 below illustrates this.

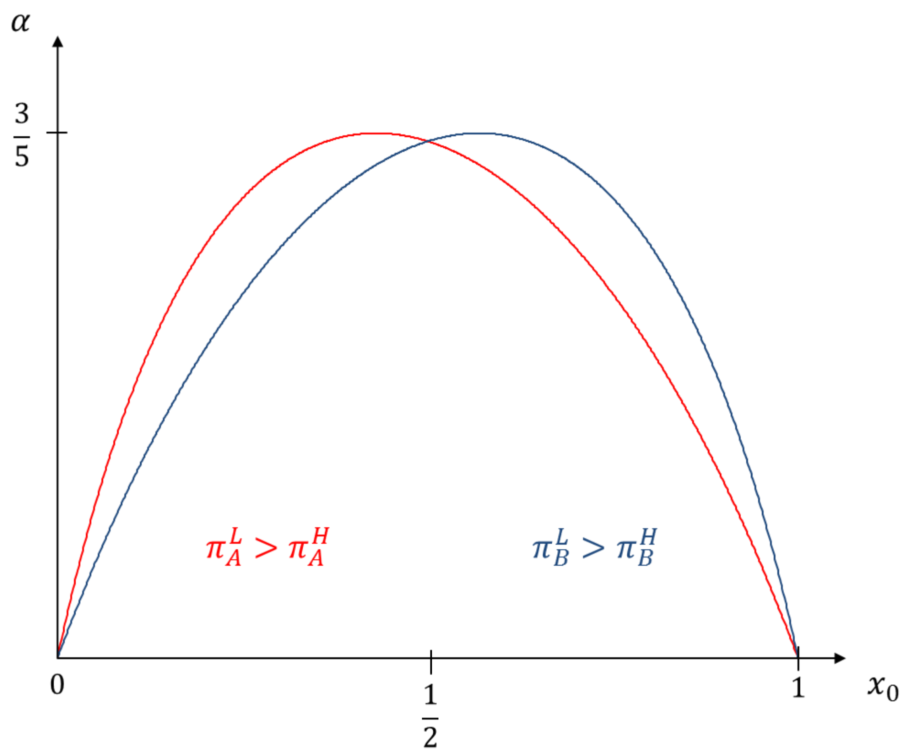

Fig. 18: comparison of equilibrium profits under history-based price discrimination, with or without 'leakage', depending on α.

In an opposite way, the comparison of the corresponding consumer surpluses under the three regimes shows the same swap in ranking between history-based price discrimination with or without 'leakage' depending on the parameter α, as Figures 19a and 19b below illustrate (by setting $V = \frac{3}{4}$).

[27] Solving the inequality $\pi_A^H - \pi_A^L \geq 0$ for α yields $\alpha \geq \frac{16x_0(x_0-1)}{(x_0-2)(5x_0+2)}$. Solving the same inequality for firm B gives $\alpha \geq \frac{16x_0(x_0-1)}{(x_0+1)(5x_0-7)}$.

[28] When inherited market shares are highly asymmetric, 'best-response asymmetry' drives firms' pricing strategies notwithstanding the imposition of leakage.

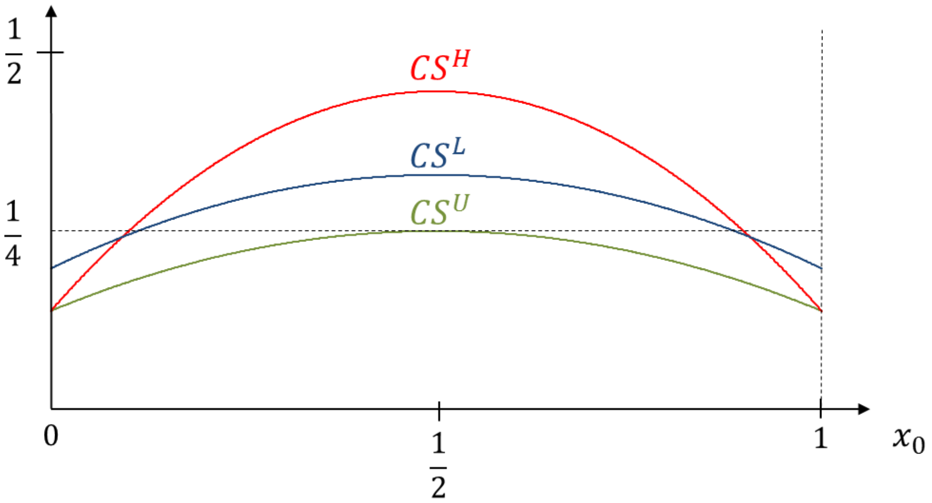

Fig. 19a: comparison of consumer surpluses under the three pricing regimes, for $\alpha = \frac{1}{4}$.

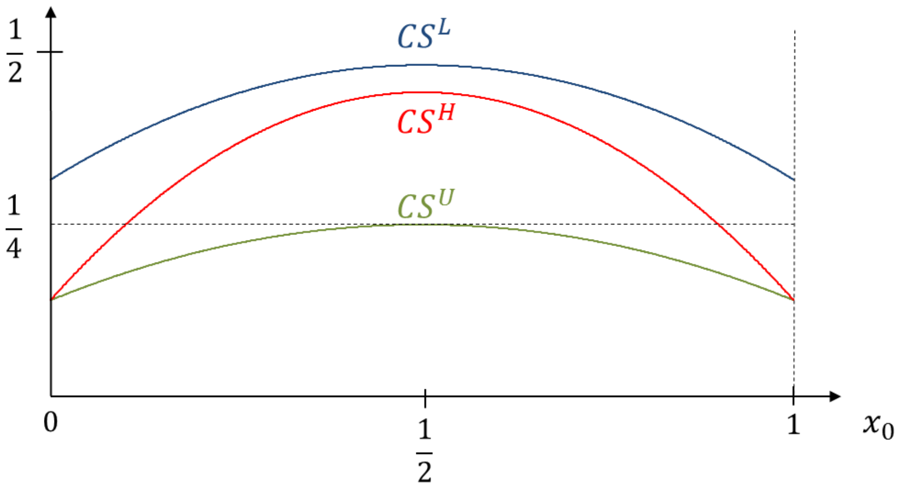

Fig. 19b: comparison of consumer surpluses under the three pricing regimes, for $\alpha = \frac{3}{4}$.

Figure 20 below illustrates how the comparison between consumer surpluses under history-based price discrimination, with or without leakage, depends on the parameter α,[29] and how this relationship differs very little from the impact that 'leakage' has on firms' profitability.

[29] Solving the inequality $CS^H - CS^L \geq 0$ for α yields $\alpha \leq \frac{72x_0(x_0-1)}{22x_0{}^2-22x_0-17}$.

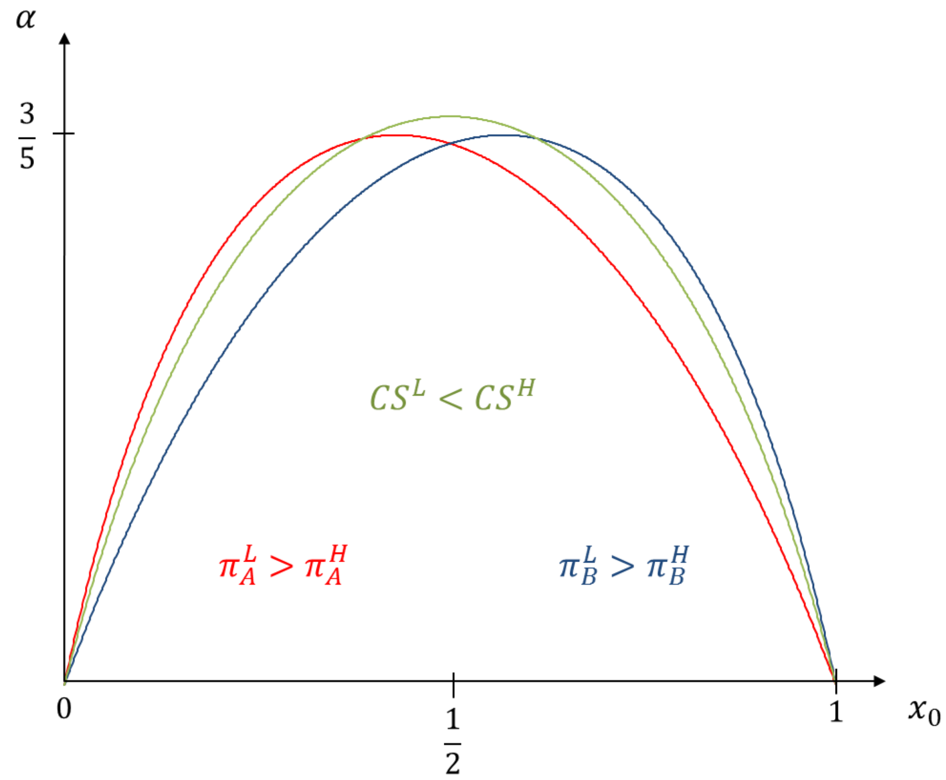

Fig. 20: comparison of consumer surpluses and equilibrium profits under history-based price discrimination, with or without 'leakage', depending on α.

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.[30] 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.

Indeed, it could be argued that firms may want to allow 'leakage' themselves as a way to soften pricing rivalry under history-based price discrimination. Indeed, as discussed in the introduction, the use of 'leakage' is reminiscent of the use of contemporaneous MFCC where consumers face heterogeneous 'hassle' cost to exercise the insurance against the event that the current service provider lowers prices for other customers. The incentive compatibility of this strategy is explored in the next section.

2.1 Unilateral incentives to permit 'leakage'

[30] In this respect, it is not surprising that calls for regulatory intervention aimed at facilitating or even imposing internal switching are typically made in cases where consumer search costs are high because of too many tariffs with different formats, which makes it very difficult to identify the best one based on the individual consumption profile. Therefore, it could be argued that the main rationale for the imposition of measured designed to facilitate internal switching is removing the incentives to engage in tariff proliferation as a way of obfuscating prices and thus soften price competition by artificially increasing consumer search costs (see Siciliani, 2014).

To understand under what circumstances a firm would have the incentive to unilaterally permit 'leakage' in an attempt to soften pricing rivalry under symmetric history-based price discrimination it is necessary to compute the profit of the firm in question, say firm A, when the rival firm does not follow suit. Accordingly, the objective functions for customers attached to firms A and B are given by, respectively:

$$max\{V - p_{Al}, V - p_{Ap} - \alpha s(x_0 - x), V - p_{Bp} - s(x_0 - x)\} \text{ and} \tag{30a}$$

$$max\{V - p_{Bl}, V - p_{Ap} - s(x - x_0)\}. \tag{30b}$$

Firm's profits are given by:

$$\pi_A^{L/H} = \begin{cases} p_{Al}\left(x_o - \frac{p_{Al}-p_{Ap}}{\alpha s}\right) + p_{Ap}\left(\frac{p_{Al}-p_{Ap}}{\alpha s} - \frac{p_{Ap}-p_{Bp}}{s(1-\alpha)} + \frac{p_{Bl}-p_{Ap}}{s}\right) \; if \; \frac{p_{Al}-p_{Ap}}{\alpha s} \geq \frac{p_{Ap}-p_{Bp}}{s(1-\alpha)} \\ p_{Al}\left(x_o - \frac{p_{Al}-p_{Bp}}{s}\right) + p_{Ap}\left(\frac{p_{Bl}-p_{Ap}}{s}\right) \; if \; \frac{p_{Al}-p_{Ap}}{\alpha s} < \frac{p_{Ap}-p_{Bp}}{s(1-\alpha)} \end{cases} \text{ and}$$

$$\pi_B^{H/L} = \begin{cases} p_{Bl}\left(1 - x_o - \frac{p_{Bl}-p_{Ap}}{s}\right) + p_{Bp}\frac{p_{Ap}-p_{Bp}}{s(1-\alpha)} \; if \; \frac{p_{Al}-p_{Ap}}{\alpha s} \geq \frac{p_{Ap}-p_{Bp}}{s(1-\alpha)} \\ p_{Bl}\left(1 - x_o - \frac{p_{Bl}-p_{Ap}}{s}\right) + p_{Bp}\frac{p_{Al}-p_{Bp}}{s} \; if \; \frac{p_{Al}-p_{Ap}}{\alpha s} < \frac{p_{Ap}-p_{Bp}}{s(1-\alpha)} \end{cases}. \tag{31}$$

The second components of both profit functions are equivalent to those under symmetric history-based price discrimination. The 'poaching' price set by firm A is too high to trigger any internal switching, that is, because it is tied to the rival's 'locked-in' price rather than, defensively, to the 'locked-in' price offered by the same firm. Firm A can plausibly decide to do so thanks to the fact that, under this asymmetric configuration, it does not have to undercut its rival's 'poaching' price in order to trigger external switching. This is likely to be the case when firm A has inherited a smaller market share, which entails that maximising revenue over newly acquired customers is more important than defending attached ones. The first components of the profit expression for firm A is as under the common permission of 'leakage' but for the fact that in the quantity expression within brackets in the second term corresponding to the 'poaching' price there always is a third term corresponding to the genuine 'poaching' of rival's customers by undercutting its 'locked-in' price. Correspondingly, firm B triggers external switching by undercutting firm A's 'poaching' price.

Figure 21 below illustrates this configuration.

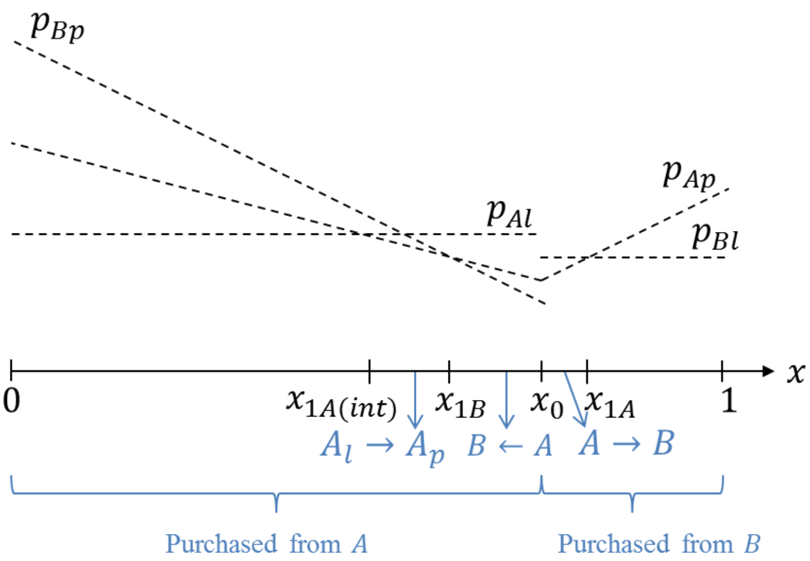

Fig. 21: spatial model of switching costs with history-based price discrimination with and without 'leakage'.

Only the sloping curve corresponding to the 'poaching' price of firm A has an additional shallower segment over the customer base of the firm in question. Therefore, internal switching can takes place (ie, under the first limbs of firms profit functions) only in one direction, whereas external switching occurs in both directions.

We can solve for the equilibrium under the first components in Eq. (31) and then compare against, respectively, firm A's profit under the common use of history-based price discrimination without 'leakage', and firm B's profit under the common use of history-based price discrimination with 'leakage'. Accordingly, solving firms' pairs of FOCs, $\frac{\partial \pi_A^{L/H}}{\partial p_{Al}} = 0$ and $\frac{\partial \pi_A^{L/H}}{\partial p_{Ap}} = 0$, and $\frac{\partial \pi_B^{H/L}}{\partial p_{Bl}} = 0$ and $\frac{\partial \pi_B^{H/L}}{\partial p_{Bp}} = 0$ for $\frac{p_{Al}-p_{Ap}}{\alpha s} \geq \frac{p_{Ap}-p_{Bp}}{s(1-\alpha)}$, yields:[31]

$$p_{Al}^{L/H} = \frac{\alpha s x_o}{2} + \frac{s(1-\alpha)(x_o+1)}{3(2-\alpha)} \text{ and } p_{Ap}^{L/H} = \frac{s(1-\alpha)(x_o+1)}{3(2-\alpha)}, \text{ and}$$

$$p_{Bl}^{H/L} = \frac{(1-x_o)s}{2} + \frac{s(1-\alpha)(x_o+1)}{6(2-\alpha)} \text{ and } p_{Bp}^{H/L} = \frac{s(1-\alpha)(x_o+1)}{6(2-\alpha)}, \tag{32}$$

where the condition $\frac{p_{Al}-p_{Ap}}{\alpha s} \geq \frac{p_{Ap}-p_{Bp}}{s(1-\alpha)}$ is satisfied for $x_o \geq \frac{1}{5-3\alpha}$. The main thing to notice is that the expressions for $p_{Al}^{L/H}$ and $p_{Ap}^{L/H}$ are very similar to the ones for p_{Al}^{L} and p_{Ap}^{L} under the common permission of 'leakage', but for the fact that the second additive term has a larger denominator because of the factor $(2-\alpha)$. That is to say, Firm A sets prices that are systematically lower than under the previous configuration.

Firms' equilibrium profits are given by:

[31] It is straightforward to verify that the corresponding second order conditions are satisfied.

$$\pi_A^{L/H} = \frac{\alpha s {x_o}^2}{4} + \frac{s(1-\alpha)(x_o+1)^2}{9(2-\alpha)} \text{ and } \pi_B^{H/L} = \frac{s(1-x_o)^2}{4} + \frac{7s(1-\alpha)(x_o+1)^2}{36(2-\alpha)}. \quad (33)$$

Figures 22a and 22b compare firms' profits in Eq. (33) against, respectively, firm A's profit under the common use of history-based price discrimination without 'leakage', and firm B's profit under the common permission of 'leakage', for $\alpha = \frac{1}{4}, \frac{3}{4}$ (and by setting $s = 1$).

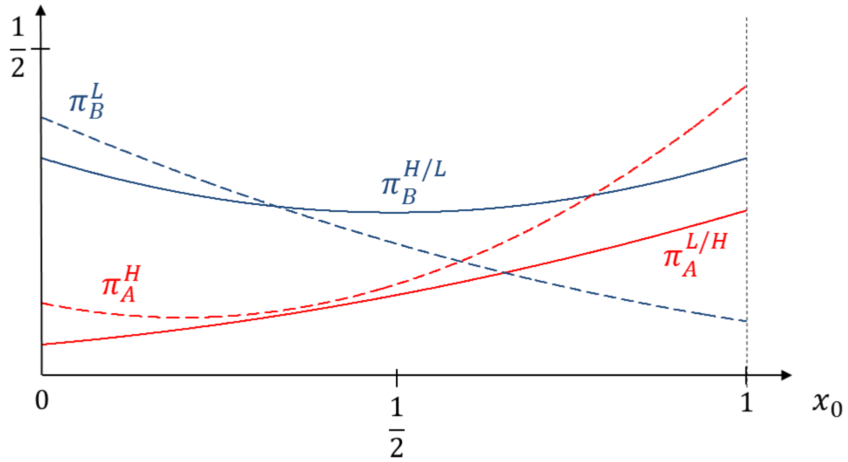

Fig. 22a: comparison of equilibrium profits under symmetric and asymmetric regimes, for $\alpha = \frac{1}{4}$.

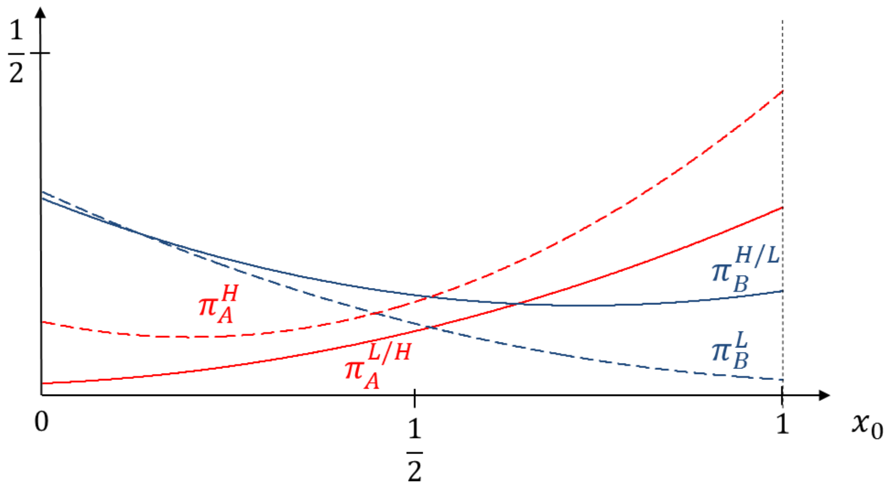

Fig. 22b: comparison of equilibrium profits under symmetric and asymmetric regimes, for $\alpha = \frac{3}{4}$.

Firm A lacks the unilateral incentive to allow 'leakage'. This was obvious in light of the fact that, as for prices, the expression for $\pi_A^{L/H}$ is very similar to the expression for π_A^H under the common permission of 'leakage', but from the fact that the second additive term has a larger denominator because of the factor $(2 - \alpha)$. Therefore, it can be argued that, for sufficiently low values of α (refer to Figure 18), firms face another Prisoners'

Dilemma in that they would be collectively better off by both permitting 'leakage' but each firm has a unilateral incentive not to do so.

Firm B lacks the incentive to match the permission of 'leakage' unless it has inherited a very large market share under sufficiently high relative convenience of internal switching. Intuitively, for firm B to find matching the permission of 'leakage' profitable requires that the defensive use of the 'poaching' price is sufficiently effective in preserving a large enough inherited market share. Otherwise, this effect is dominated by the fact that, by not being constrained by its own 'poaching' price, the firm in question can sets its 'locked-in' price above the rival's 'poaching' price, which is higher (i.e., closer to the rival's own 'locked-in' price) the higher the relative convenience of internal switching and the higher the market share inherited by the rival.

Therefore, the firm with the smaller inherited market share will have to move first by unilaterally allowing the permission of 'leakage', and thus temporarily reducing its profits, until the larger firm matches the permission of 'leakage'.[32] This is because the larger firm will never do so in the knowledge that the smaller rival will not want to reciprocate, in that its profit under the asymmetric pricing regime is materially higher than if it matched the permission of 'leakage'. That is to say, the smaller firm has to commit first to the permission of 'leakage',[33] and may be willing to do so only to the extent that its profit under the symmetric use of history-based price discrimination with 'leakage' is higher than without it. Figure 23 below illustrates this.[34]

[32] This is arguably a risky strategy for the smaller firm, perhaps motivated by the desire to escape the early-growth trap under symmetric history-based price discrimination. The larger one might decide not to match the permission of 'leakage' in order to weaken the smaller rival. This is particularly the case where the incremental profit that the larger firm would gain in the case of matching is small.

[33] This observation calls into question whether the permission of 'leakage' is irreversible, and thus credible. This may be the case if the decision to withdraw the possibility to upgrade to a different tariff has reputational costs.

[34] Solving the inequality $\pi_B^L - \pi_B^{H/L} \geq 0$ for α yields $\alpha \leq \frac{17{x_0}^2+10x_0-7}{5{x_0}^2-2x_0-7}$.

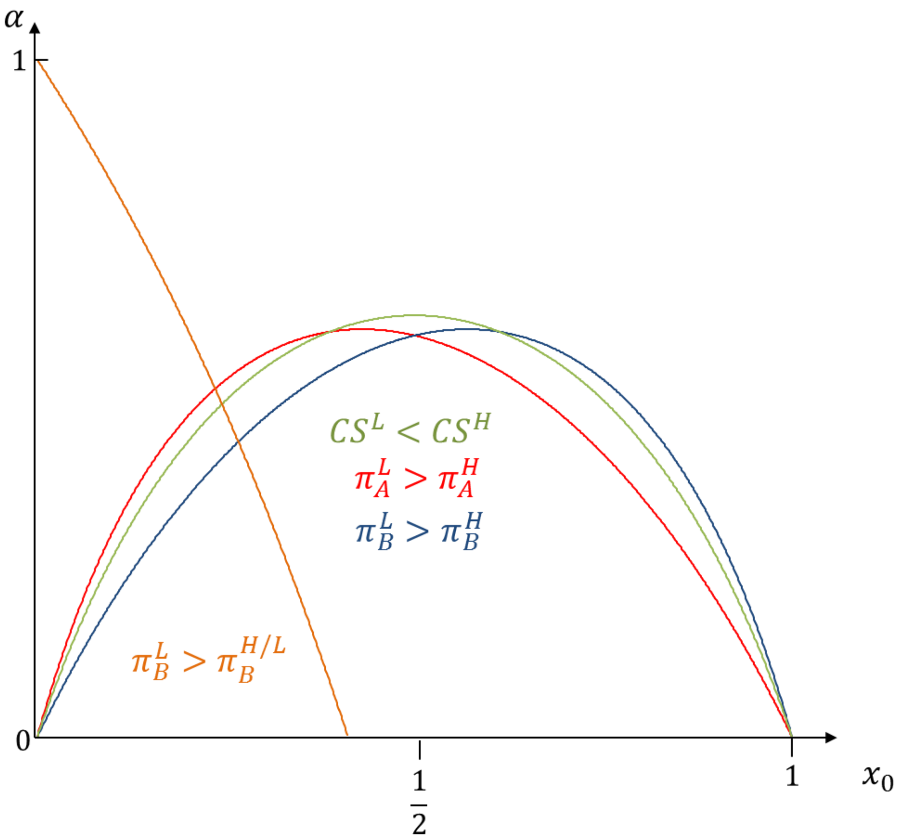

Fig. 23: analysis of unilateral incentives to permit 'leakage' depending on α.

The simile-triangular area encapsulated by the red and orange lines, and the horizontal axis, represents the combinations of α and x_0 that can give rise to the common permission of 'leakage' even in the absence of regulatory intervention.[35] 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 α, primarily at the expense of its 'locked-in' customers.

As mentioned above, the use of 'leakage' as a defensive strategy is reminiscent of the contemporaneous use of a MFCC where customers face heterogeneous 'hassle' costs to claim for compensation, so that it translates into a form of second-degree price discrimination. To the best of our knowledge there is no extant economic literature researching this setting.[36] Besanko and Lyon (1993) analysed firms' incentives to adopt contemporaneous 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 setting $\alpha = 0$, which equates to setting uniform prices. The authors show that there can

[35] Of course, there is a specular partition when it is firm B that considers whether to unilaterally permit 'leakage'.

[36] See Lear (2012), paras 3.46-3.47 at p. 53). The same applies to whether the use of MFCC can have foreclosing effects (i.e., deter entry or forestall expansion). See Lear (2012, paras 3.16 at p. 44).

be configurations where firms have a unilateral incentive to use contemporaneous MFCC. They also show that the use of contemporaneous MFCC 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 the 'band-wagon' effect identified by the authors, but only for a limited set of parameters, we find that the firms lack the incentives to trigger the 'band-wagon' effect.

3 Conclusion

We adopt a spatial model approach to analyse the impact of switching costs in a tractable way, whilst allowing for heterogeneity in the distribution of switching costs not only across consumers, but also across firms' customer bases. We model three different pricing regimes: uniform pricing; history-based price discrimination; and history-based price discrimination but with 'leakage', where firms cannot prevent attached customers from upgrading to the better deal launched to acquire new customers. Much in the spirit of the earlier literature,[37] we find that prices unambiguously increase with switching costs. The use of price discrimination is beneficial to consumers, when compared to the regime under uniform prices. However, the imposition of 'leakage' might inadvertently dissipate much of these benefits when internal switching is much more convenient than switching (externally) to a competitor.

In contrast to the extant literature, firms always lack the unilateral incentives to adopt history-based price discrimination under the common use of uniform pricing. We find instead that the transition towards the common use of history-based price discrimination can be the result of firms erring on the side of caution, that is, to avoid the risk of being exposed to a firm unilaterally adopting it. Similarly and in contrast with the extant literature, firms always lack unilateral incentives to voluntarily permit 'leakage' - that is, similarly to the adoption of contemporaneous MFCC – even they they would be collectively better off if both did when internal switching is much more convenient.

We are currently working on the extension over a second period. Possible other extensions are: to model more than two firms, by adopting a radial spatial framework; to assume that there is a cap on switching costs (ie, so that the sloping pricing schedules become trapezoidal in shape); and to model different distributions of heterogeneous switching costs (ie, modelling different densities of consumers across various distances from x_0).

[37] As in Beggs and Klemperer (1992).

References

Armstrong, M.C. “Recent Developments in the Economics of Price Discrimination.” In Blundell, R., W.K. Newey and T. Persson, *Advances in Economics and Econometrics: Theory and Applications, Ninth World Congress of the Econometric Society*, vol. 2, Cambridge University Press, 2006.

Beggs, A.W. and P. Klemperer “Multi-period competition with switching costs.” *Econometrica*, Vol. 60 (1992), pp. 651–666.

Besanko, D. and T.P. Lyon “Equilibrium incentives for most-favored customer clauses in an oligopolistic industry.” *International Journal of Industrial Organization*, Vol. 11 (1993), pp. 347-367.

Biglaiser, G., J. Crémer and G. Dobos “Heterogeneous switching costs.” *International Journal of Industrial Organization*, Vol. 47 (2013), pp. 62-87.

Biglaiser, G., J. Crémer and G. Dobos “The value of switching costs.” Jo*urnal of Economic Theory*, Vol. 148 (2016), pp. 935-952.

Cabral, L. “Dynamic pricing in customer markets with switching costs.” *Review of Economic Dynamics*, Vol. 20 (2016), pp. 43-62.

CMA (2016a), *Retail banking market investigation – Final report*, available at https://www.gov.uk/cma-cases/review-of-banking-for-small-and-medium-sized-businesses-smes-in-the-uk.

CMA (2016b), Energy market investigation – Final report, available at https://www.gov.uk/cma-cases/energy-market-investigation.

Fabra, N. and A. García “Market structure and the competitive effects of switching costs.” *Economic Letters*, Vol. 126 (2015), pp. 150-155.

Farrell, J. and P. Klemperer "Coordination and lock-in: Competition with switching costs and network effects." In Armstrong, M. and R. Porter (Eds.), *Handbook of Industrial Organization*, vol. 3 Elsevier, 2007.

FCA (2016a), *Our response to the CMA's final report on its investigation into competition in the retail banking market*, available at https://www.fca.org.uk/publication/corporate/response-cma-final-report-competition-retail-banking-market.pdf.

FCA (2016b), *Cash Savings Market Study Update*, available at https://www.fca.org.uk/publication/market-studies/ms14-02-4-update.pdf.

Gehrig, T., O. Shy, and R. Stenbacka "A Welfare Evaluation of history-Based price Discrimination." *Journal of Industry, Competition and Trade*, Vol. 12 (2012), pp. 373-393.

Lear (2012), *Can 'Fair' Prices Be Unfair? A Review of Price Relationship Agreements*, available at http://www.learlab.com/pdf/oft1438_1347291420.pdf.

Pearcy, J. "Bargains followed by bargains: when switching costs make markets more competitive." *Journal of Economics & Management Strategy*, Vol. 25 (2015), pp. 826-851.

Rhodes, A., "Re-examining the effects of switching costs." *Economic Theory*, Vol. 54 (2014), pp. 161-194.

Siciliani, P "Confusopoly and the fallacies of behaviouralism – a response to Littlechild and Hviid & Waddams Price." *European Competition Journal*, Vol. 10 (2014), pp. 419-434.

Somaini, P. and L. Einav "A Model of Market Power in Customer Markets." Jou*rnal of Industrial Economics*, Vol. 61 (2013), pp. 938-986.

Stole, L.A., “Price Discrimination and Competition.” In Armstrong, M. and R. Porter (Eds.), *Handbook of Industrial Organization*, vol. 3 Elsevier, 2007.

Thisse, J.-F. and X. Vives “On the strategic choice of spatial price policy.” *American Economic Review*, Vol. 78 (1988), pp. 122-137.