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Size-based wholesale price discrimination under endogenous inside options*

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Abstract

Individual retailers may choose to invest in a substitute to a dominant supplier's products (inside option) as a way of improving its position towards the supplier. Given that a large retailer has stronger investment incentives than a small retailer, a large retailer may obtain a selective rebate (size-based price discrimination). We study the incentives of dominant suppliers to commit to uniform pricing in wholesale markets. The seminal literature on wholesale price discrimination has provided clear-cut results when the source of wholesale price discrimination is inside options: a dominant supplier will commit to uniform wholesale pricing, and consumers will be harmed. In a model with endogenous inside options and differentiated retailers, we show that the outcome is ambiguous. We confirm the result if retailers are close substitutes. If, however, the retailers are weak substitutes, the outcome flips around. Consumers are better off under uniform pricing, but the supplier has no incentives to commit to uniform pricing. Interestingly, for an intermediate level of substitutability among the retailers, supplier and consumer interests can coincide.

Keywords: Wholesale price discrimination, size asymmetries, retail competition, inside options.
JEL classification: D21, L11, L13

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1 Introduction

Size-based wholesale price discrimination in favor of large retailers is an age-old issue and takes place in a large array of industries. Walmart's success, for instance, has been partly explained by the advantageous wholesale prices it has enjoyed due to its size (see e.g. Basker, 2007; Ellickson, 2016; Dukes, Gal-Or, and Srinivasan, 2006); a ten percent increase in volume reduces Walmart's marginal upstream costs by two percent (Basker, 2007). Likewise, Amazon exploits its power as a large retailer to obtain low wholesale prices in the book-publishing market (Gilbert, 2015), and in the US multi-channel television market, the per-customer wholesale prices for a large firm like Comcast could be 25 percent lower than those faced by smaller firms (Crawford and Yurukoglu, 2012; Doudchenko and Yurukoglu, 2016). Finally, the UK competition authorities found a significant negative relationship between size in grocery retailing and unit wholesale prices (Competition Commission, 2008).[1]

Individual retailers may threaten to switch to an alternative source of supply instead of buying the product from the dominant supplier. If this is credible, the dominant supplier must lower the wholesale price to keep the retailer onboard. If one retailer has better access to an alternative than the other retailer, the supplier will price discriminate in favor of this retailer. However, it is not obvious that the supplier wants to price discriminate. In this paper, we investigate under what conditions a dominant supplier benefits from price discrimination, and when the supplier prefers to commit to uniform pricing. To analyze this, we set up a simple model for a wholesale market. There are two identical and independent local markets. A small retailer is present in each local market, while a large retailer has an outlet in both markets. We allow the retailers to be differentiated. The retailers are offered a product from a dominant supplier that they can resell to the consumers. Prior to the supplier's decision on wholesale prices, the retailers may invest in reducing the marginal costs of an alternative to the supplier's product, in order to put pressure on the supplier to lower wholesale prices. We label this alternative as an "inside option". Investing in marginal-cost reductions on the inside option is more profitable for the large retailer, all else equal, since it benefits from larger marginal benefits in total for all

[1] The Norwegian Competition Authority (2019) conducted a comprehensive study of wholesale prices in the grocery market. From 14 out of the 16 suppliers investigated—most of them dominant suppliers—the largest retail chain obtains a selective unit cost rebate (the differences were in the range 0–10 percent from 10 suppliers, 10–15 percent from three suppliers, and above 15 percent from one supplier).

the locations in which it operates. The model thus endogenizes the inside option, resulting in inside option asymmetries and, consequently, size-based wholesale price discrimination in favor of the largest retailer.

We find that the supplier is worse off, whereas consumers benefit from price discrimination if the retailers are sufficiently close substitutes. For a low level of substitutability among retailers, the outcome flips around. If the substitutability becomes sufficiently small, the consumers benefit if the supplier commits to uniform pricing (or restrictions on price discrimination are imposed by the authorities), but the supplier has no incentives to make such a commitment. Interestingly, however, for an intermediate level of substitutability, supplier and consumer interests can coincide.

The intuition for the results is as follows. Since a large retailer has stronger incentives to invest in inside options than a smaller retailer, a smaller retailer is therefore, under uniform pricing, free-riding on the large retailer's investment in inside options, and consequently never invest under uniform pricing. When the retailers are unrelated, the investment, and consequently the wholesale price for the large retailer, is equal under uniform pricing and price discrimination. The small retailers will obtain the same wholesale price as the large retailer under uniform pricing, but the (higher) unconstrained wholesale price under price discrimination. This explains why consumers are better off with uniform pricing when the substitutability among the retailers becomes too small.

As the retailers become closer substitutes, the large retailer will invest more under price discrimination (business-stealing) and less under uniform pricing (since the investment spillover makes the smaller rivals more aggressive). A commitment to uniform pricing reduces the retailers' investment incentives (ex ante), which allows the supplier to raise its wholesale price. Consequently, uniform pricing becomes relatively more attractive for the supplier as the retailers become closer substitutes. This explains why the incentives of the supplier shift, and that supplier and consumer interests therefore can coincide for an intermediate level of substitutability.

Thereby we complement earlier contributions on who benefits from size-based wholesale price discrimination. The literature shows that this critically depends on whether the source of such price discrimination is related to inside or outside options. Akgün and Chioveanu (2019) consider investments in inside options, in a model that is closely related to ours, and find consumers are better off—while the supplier is worse off—if the supplier can price discriminate. Consequently, the supplier would benefit from the ability to commit to uniform pricing. In contrast to us, however, Akgün and Chioveanu (2019) consider symmetric retailers. In their equilibrium, the retailers have the same investment incentives, and therefore choose the same investment level and pay the same wholesale price. Consequently, both retailers prefer price discrimination over uniform pricing. Since the retailers' investments are the same, the supplier would be indifferent between price discrimination and uniform pricing when the retailers are unrelated. Consequently, Akgün and Chioveanu (2019) show that their result holds for all levels of substitutability. We show how this changes when the retailers differ in size.

Retailers can also invest in outside options after the wholesale prices have been determined. As long as the outside option is binding for at least the larger retailer, Katz (1987) show that consumers are better off under uniform pricing, while the supplier prefers to have the ability to price discriminate.[2] The reason is that the threat of choosing the outside option does not disappear if the supplier cannot use price discrimination, and the supplier needs to provide a lower wholesale price to all retailers to ensure that the large retailer does not go for the outside option. O'Brien (2014) extends the framework of Katz (1987) to a bargaining framework. If an outside option is binding, his results resemble those of Katz (1987). If the source of price discrimination instead is (exogenously given) asymmetries in inside options, and the outside option is not binding, the supplier prefers uniform pricing, while consumers are better off with price discrimination.

Size-based wholesale price discrimination has been a controversial antitrust issue dating back to the Robinson-Patman Act of 1936. Katz (1987), O'Brien (2014), and Akgün and Chioveanu (2019) leave us with some clear-cut results that seemingly provide a simple rule of thumb for competition authorities:[3] Dig into the source of size-based price discrimination. If it becomes apparent that the source relates to outside options, further analyses should be undertaken, since consumers may be harmed. In contrast, if the source of size-based price discrimination relates to inside options, pressure from, e.g., small retailers, to put restrictions on suppliers' ability to use price discrimination should be dismissed. We show that this finding is too simplistic, however, even if the source of size-based price

[2]The large retailer prefers price discrimination, while the smaller retailer prefers uniform pricing under both inside and outside options.

[3]In contrast to us, both Katz (1987) and O'Brien (2014) consider Cournot competition, where the retailers are perfect substitutes.

discrimination is inside options.[4]

2 The model

We consider a setting with two identical and independent local markets, $k = \{A, B\}$. In each market, k, there is a small retailer, S, which only operates locally. There is also a large retailer, L, which is present in both markets. A dominant upstream supplier, U, offers each retailer a product that it can resell to the consumers. If retailer $i = \{S, L\}$ buys the product from the supplier, it is charged a unit wholesale price, w_i, by the supplier.[5] We normalize retailing costs to zero.

Rather than buying from the supplier, retailer i can produce a substitutable product in-house if it has previously made an adequate investment. In the words of O'Brien (2014), the retailer thus has an inside option. Let o_i denote the marginal cost of producing this

[4]Large retailers may also achieve a rebate compared to smaller retailers if it faces increasing marginal costs in the relevant area (Chipty and Snyder, 1999, and subsequent papers). Asymmetries in retail efficiency, however, cannot explain size-based price discrimination in favor of the large retailer. Quite the opposite; DeGraba (1990), Katz (1987), and Akgün and Chioveanu (2019) show that an unconstrained supplier will price discriminate in favor of the less efficient retailer. If the retailers can invest prior to the decision on wholesale prices to reduce retail marginal costs, DeGraba (1990) shows that retailers invest less under price discrimination than under uniform pricing. The reason is that the more a retailer invests in retail marginal-cost reductions, the greater the level of price discrimination in disfavor of the more efficient retailer. In our set-up, we deliberately assume that retailers are equally efficient at the retail level. Consequently, differences in retail marginal costs are not a source of price discrimination in our model.

[5]While real-world contracts typically involve more than a simple unit wholesale price, linear wholesale pricing seems to be a more reasonable assumption than non-linear contracts in many markets. One example is grocery retailing. Even though the contracts between suppliers and retailers are complex, comprehensive investigations by competition authorities in the UK and Norway (Competition Commission, 2008; Norwegian Competition Authority, 2019) reveal that rebates are given at the margin and that (average) variable wholesale price components are decreasing in size (see also discussion by Inderst and Valletti, 2009). Linear wholesale price contracts are also widely used in cable television markets (Crawford and Yurukoglu, 2012; Crawford et al., 2018; Doudchenko and Yurukoglu, 2016) and in the book-publishing industry (see e.g. Gilbert, 2015). Further examples are provided by Gaudin (2019). Iyer and Villas-Boas (2003) provide a theoretical rationale for using linear wholesale pricing. Under non-linear pricing, whether or not wholesale contracts are secret is a crucial consideration. Under secret contracts, O'Brien and Shaffer (1992; 1994) show that there will be no price discrimination at the margin from an unconstrained supplier. Instead, wholesale prices at the margin equal the supplier's marginal cost. In contrast to the outcome under non-linear pricing, Gaudin (2019) shows that consumer prices may be higher under secret than under observable (and credible) linear wholesale prices. Most of the papers on wholesale price discrimination under non-linear contracts assume an unconstrained supplier. One exception is Inderst and Shaffer (2019), who show that if retailers have access to outside options, the supplier may reduce the unit wholesale price, and increase the fixed slotting fee, towards one of the retailers, thereby reducing the value of the outside options for all other retailers.

inside option:

$$o_i = c - x_i, \text{ where } i, j = S, L; i \neq j, \tag{1}$$

where c is the gross marginal cost, and x_i reflects the investment in marginal-cost reduction by retailer i. The net profit of the small and large retailers, respectively, are

$$\pi_S = (p_S^k - z_S^k)q_S^k - C(x_S) \tag{2}$$

and

$$\pi_L = (p_L^A - z_L^A)q_L^A + (p_L^B - z_L^B)q_L^B - C(x_L), \tag{3}$$

where $z_i = \min\{w_i, o_i\}$. The cost of investing in a marginal-cost reduction of x_i is $C(x_i)$, where C is strictly increasing and strictly convex, $C' > 0, C'' > 0$. More specifically, we define $C(x_i)$ in the following way:

$$C(x_i) = \frac{\gamma}{2}x_i^2. \tag{4}$$

We normalize all costs for the supplier to zero, so that its profit level in each local market is given by:

$$u = w_S q_S + w_L q_L. \tag{5}$$

In each local market, consumer preferences are defined by a Shubik-Levitan (1980) utility function:[6]

$$\Psi(q_S^k, q_L^k) = 2(q_S^k + q_L^k) - (1-s)\Big(\left(q_S^k\right)^2 + \left(q_L^k\right)^2\Big) - \frac{s}{2}(q_S^k + q_L^k)^2,$$

where $s \in [0,1]$ reflects the degree of substitutability between the outlets. Consumer surplus in a representative market is given by

$$CS = \Psi(q_S^k, q_L^k) - p_S^k q_S^k - p_L^k q_L^k. \tag{6}$$

[6]The demand system by Shubik and Levitan (1980) has an attractive property, as it enables us to vary the degree of substitution among retailers without affecting the size of the market (see e.g., the discussion in Inderst and Shaffer, 2019).

Solving $\partial CS/\partial q_i^k = 0$, we find the inverse demand functions

$$p_i^k = 2 - (1-s)2q_i^k - s(q_S^k + q_L^k).$$

The timing of the game is as follows:

- Stage 1: The retailers decide how much to invest in the inside option (S and L choose x_S and x_L, respectively).
- Stage 2: The supplier sets the wholesale prices: (i) w_S^{PD} and w_L^{PD} under price discrimination (PD) and (ii) w^{UP} under uniform pricing (UP).
- Stage 3: Cournot competition in each local market. S and L choose q_S^k and q_L^k, respectively.

The game is solved by backward induction.

Our aim here is to focus on who benefits from uniform pricing. If the supplier benefits, we may expect it to commit to uniform pricing, if it is abile to do so. A commitment to uniform pricing could, for instance, be achieved by signing a wholesale most-favored nation (MFN) clause with a small retailer. If consumers benefit from uniform pricing, an important policy issue is thus whether the authorities should restrict the supplier's ability to price discriminate.

It is straightforward to show that if the inside options are non-binding for both retailers, which means there will be no investments (NI), the solution of $\max_{w_S,w_L} u$ gives the following unconstrained equilibrium:[7]

$$w^{NI} = 1 \text{ and } q^{NI} = \frac{1}{4-s}. \tag{7}$$

To ensure that the retailers buy from the supplier if there are no investments, we make the following assumption throughout the paper:

Assumption 1 $c > \underline{c} = 1$.

[7]Hence, we have $\pi_S^{NI} = (2-s)\left(q^{NI}\right)^2$, $\pi_L^{NI} = 2\pi_S^{NI}$. Profit to the supplier in each local market is $u^{NI} = 2q^{NI}$.

Furthermore, we want to avoid the trivial unconstrained case given by Equation (7). The large retailer has several outlets. Investing in reducing the marginal costs on the inside option is therefore more profitable for the large retailer, all else equal, since it benefits from larger marginal benefits in total for all the locations in which it operates. Therefore, the inside option must bind for at least the large retailer. In the basic model, we further assume that the inside option is binding for only the large retailer:

Assumption 2 $c \in (\bar{c}_S, \bar{c}_L]$,

where

$$\bar{c}_L = 2 - \frac{\sqrt{\gamma(9\gamma - 4)}}{3\gamma} \text{ and } \bar{c}_S = 2 - \sqrt{\frac{4\gamma - 1}{4\gamma}}. \tag{8}$$

In Appendix A.4.1, we show that $c \leq \bar{c}_L$ is a sufficient condition to ensure that the inside option is binding for the large retailer. The condition $c > \bar{c}_S$ is sufficient to ensure that the small retailer does not invest. We relax the latter assumption in an extension (Section 3).

Further, we assume the following throughout the paper:

Assumption 3 $\gamma > \frac{8}{3}$.

Assumption 3 is the sufficient condition for second-order conditions and stability in equilibrium.

2.1 Stage 3: Cournot

By solving $\partial\pi_S/\partial q_S^k = 0$ and $\partial\pi_L/\partial q_L^k = 0$ from (2) and (3), respectively, we find the equilibrium output in each local market k:

$$q_i^k = \frac{2(4-3s) - 2(2-s)z_i + sz_j}{(4-s)(4-3s)}. \tag{9}$$

Since the local markets are identical, we may now for simplicity define $p_i^A = p_i^B \equiv p_i$ and $q_i^A = q_i^B \equiv q_i$. This allows us to write the net profit of a representative small retailer and the large retailer, respectively, as

$$\pi_S = (2 - s)\, q_S^2 - C(x_S) \tag{10}$$

and

$$\pi_L = 2\,(2 - s)\, q_L^2 - C(x_L). \tag{11}$$

Recall from Assumption 2 that the small retailer does not invest in the basic model.

2.2 Stage 2: The supplier decides wholesale prices

The wholesale price towards the large retailer is $w_L^R = c - x_L^R$, where $R \in \{UP, PD\}$. Under uniform pricing, both retailers are charged $w^{UP} = w_L^{UP}$. Under price discrimination, the large retailer is charged

$$w_L^{PD} = o_L.$$

To find the wholesale price for the small retailer, the supplier solves

$$\max_{w_S} u \text{ s.t. } w_L^{PD} = o_L,$$

and w_S^{PD} becomes:

$$w_S^{PD} = w^{NI} - \frac{s}{2\,(2 - s)} \left(w^{NI} - \left(c - x_L^{PD} \right) \right). \tag{12}$$

A crucial mechanism is identified in Equation (12). If the consumers perceive the retailers as unrelated, $s = 0$, the supplier charges the small retailer the unconstrained wholesale price $w^{NI} = 1$ (from Equation (7)). However, if $s > 0$, the supplier will reduce w_S^{PD} below w^{NI} as long as $w^{NI} > c - x_L^{PD}$. The more the large retailer invests, the lower is $w_L^{PD} = c - x_L^{PD}$, and the more the supplier will reduce w_S^{PD}. The binding inside option for L forces the supplier to reduce w_L^{PD} as x_L^{PD} increases. Consequently, the supplier's margin is higher for sales through S than L. To transfer sales from L to S, the supplier lowers w_S^{PD}. More specifically, from Equation (12), we have:

$$\frac{\partial w_S^{PD}}{\partial x_L^{PD}} = -\frac{s}{2\,(2 - s)} < |1| \text{ and } \frac{\partial w_S^{PD}}{\partial x_L^{PD} \partial s} = -\frac{1}{(2 - s)^2} < 0.$$

Hence, we obtain the following result:

Proposition 1 *Assume price discrimination. The supplier will lower the wholesale price for the small retailer, the more the large retailer invests, $\partial w_S^{PD}/\partial x_L^{PD} < 0$ if $s > 0$, and more so the closer rivals are the retailers, $\partial w_S^{PD}/(\partial x_L^{PD}\partial s) < 0$.*

2.3 Stage 1: Investments in inside options

2.3.1 Uniform pricing

By inserting for $w^{UP} = c - x_L^{UP}$ into Equation (9) and solving $\partial\pi_L^{UP}/\partial x_L^{UP} = 0$, we find the investment and the wholesale price:

$$x_L^{UP} = \frac{2-c}{2\gamma-1} - \frac{s^2\gamma(2-c)}{(2\gamma-1)\,\Omega} \text{ and } w^{UP} = c - x_L^{UP}, \tag{13}$$

where $\Omega = 8((\gamma-1)+\gamma(1-s)) + s(4+s\gamma)$. The investment is decreasing in s, such that the wholesale price is increasing in s:

$$\frac{\partial x_L^{UP}}{\partial s} = -\frac{4s\gamma(2-c)(4-s)}{\Omega^2} < 0 \longrightarrow \frac{\partial w^{UP}}{\partial s} > 0. \tag{14}$$

The investment spillover identified in Proposition 1 does not matter to the large retailer if $s = 0$. In contrast, when the retailers compete, $s > 0$, the spillover makes the rival more aggressive, and more so the larger is s. Hence, investments from the large retailer are decreasing in s.[8]

2.3.2 Price discrimination

By inserting w_S^{PD} from (12) and $w_L^{PD} = c - x_L^{PD}$ into Equation (9), and solving $\partial\pi_L^{PD}/\partial x_L^{PD} = 0$, we find

$$x_L^{PD} = \frac{2-c}{2\gamma-1} + s\frac{1+\gamma(2-s)-\gamma(4-s)(c-1)}{(2\gamma-1)\,\Phi} \text{ and } w_L^{PD} = c - x_L^{PD}, \tag{15}$$

where $\Phi = (4-s)((\gamma-1)+\gamma(1-s))$.

[8] The sufficient critical value $\bar{c}_L$ that ensures that the inside option is binding for the large retailer—Assumption 2 above—follows from setting $\pi_{L,s=1}^{UP} = \pi_{s=1}^{NI}$. As we show, the large retailer has higher investment incentives under price discrimination. Hence, $c \leq \bar{c}_L$ ensures that the inside option is binding for the large retailer in all regimes.

The first term in the square bracket is identical to the first term in Equation (13). This reflects that the investment level is identical under uniform pricing and price discrimination when the retailers are unrelated ($s = 0$). In contrast with the outcome under uniform pricing, we now find that the x_L^{PD} is increasing in s, such that w_L^{PD} is decreasing in s:[9]

$$\frac{\partial x_L^{PD}}{\partial s} > 0 \rightarrow \frac{\partial w_L^{PD}}{\partial s} < 0. \tag{16}$$

The wholesale price towards the small retailer becomes

$$w_S^{PD} = w^{NI} - s\frac{2 - \gamma\,(4 - s)\,(c - 1)}{2\Phi}, \tag{17}$$

such that the small retailer is charged the unconstrained outcome $w^{NI} = 1$ if $s = 0$. As expected, w_S^{PD} decreases in s:[10]

$$\frac{\partial w_S^{PD}}{\partial s} < 0. \tag{18}$$

2.4 Comparison

By comparing wholesale prices under uniform pricing and price discrimination, we find:

Proposition 2 *(i) Assume that the retailers are unrelated ($s = 0$): The wholesale price for the large retailer is equal under uniform pricing and price discrimination. The small retailers will obtain the same wholesale price as the large retailer under uniform pricing, but the (higher) unconstrained wholesale price under price discrimination,* $w_{s=0}^{UP} = w_{L,s=0}^{PD} < w_{S,s=0}^{PD} = w^{NI} = 1$. *(ii) Assume that the retailers are substitutes ($s \in (0, 1]$): The uniform wholesale price is increasing with the level of substitutability, whereas the discriminatory wholesale prices for both retailers are decreasing with the level of substitutability,* $\frac{\partial w^{UP}}{\partial s} > 0$, $\frac{\partial w_L^{PD}}{\partial s} < 0$, $\frac{\partial w_S^{PD}}{\partial s} < 0$.

[9]It is straightforward to show that

$$\frac{\partial x_L^{PD}}{\partial s} = -\frac{\bar{c}_L \gamma\,(4 - s)^2}{\Phi^2} + \frac{24\gamma - 16s\gamma + 3s^2\gamma + 4}{\Phi^2} > 0.$$

[10]Differentiating Equation (17) with respect to s, we have: $\frac{\partial w_S^{PD}}{\partial s} = -\frac{2-\gamma(4-s)(c-1)}{2\Phi} - \frac{s}{2}\left(\frac{\gamma(c-1)}{\Phi} - \frac{2-\gamma(4-s)(c-1)}{\Phi^2}\frac{\partial\Phi}{\partial s}\right)$, where $\frac{\partial\Phi}{\partial s} = -\left((\gamma - 1) + \gamma(5 - 2s)\right) < 0$. Hence, both terms are negative, such that $\frac{\partial w_S^{PD}}{\partial s} < 0$.

Proof. Part (i) follows from (13), (15), (17), and (7). Part (ii) follows from (14), (16), and (18). ■

Let us first discuss part (i) of Proposition 2, where retailers are unrelated ($s = 0$). When there is no retail competition, the large retailer's investment level is independent of the pricing regime. Consumers buying from L are not affected by the pricing regime, and the supplier's profit from sale through L is also identical in both pricing regimes. The effect of uniform pricing is purely to reduce the wholesale price for the small retailer. Both the small retailer and its consumers are better off under uniform pricing. Consequently, we have the following corollary from Proposition 2:

Corollary 1 *Assume that the retailers are unrelated ($s = 0$): Consumers are better off under uniform pricing, while the supplier is better off with price discrimination.*

The supplier will therefore not want to commit to uniform pricing when the retailers offer unrelated products ($s = 0$). Hence, we do not expect uniform pricing to arise without intervention from the authorities when $s = 0$.

When s increases, we can see from part (ii) of Proposition 2 that the wholesale prices go in opposite directions in the two regimes. We illustrate how the wholesale prices change with s in Figure 1.[11] The horizontal axis measures the degree of substitutability, s, ranging from 0 (unrelated) to 1 (perfect substitutes). On the vertical axis are the wholesale prices in each regime. The wholesale price is increasing in s under uniform pricing, while the wholesale prices are decreasing in s for both retailers under price discrimination. To elucidate, if the supplier price discriminates, the large retailer will have higher investment incentives the stronger the retail competition. Larger investments force the supplier to reduce the wholesale price to the large retailer. From Proposition 1, we also know that some of these investments will spill over and also reduce the wholesale price to the small retailer. Hence, the wholesale prices are decreasing in s for both retailers under price discrimination. Uniform pricing, in contrast, removes the possibility of obtaining a competitive advantage, thereby reducing the large retailer's incentives to invest. Moreover, since the large retailer's investments make the rival (the small retailer) more aggressive—and more so the stronger

[11]The figure is illustrated with the parameter values $c = 1.025$ and $\gamma = 8$, which ensure that $c \in (max\{\underline{c}, \overline{c}_S^{PD}\}, \overline{c}_L^{UP}]$, such that the inside option is only binding for the large retailer.

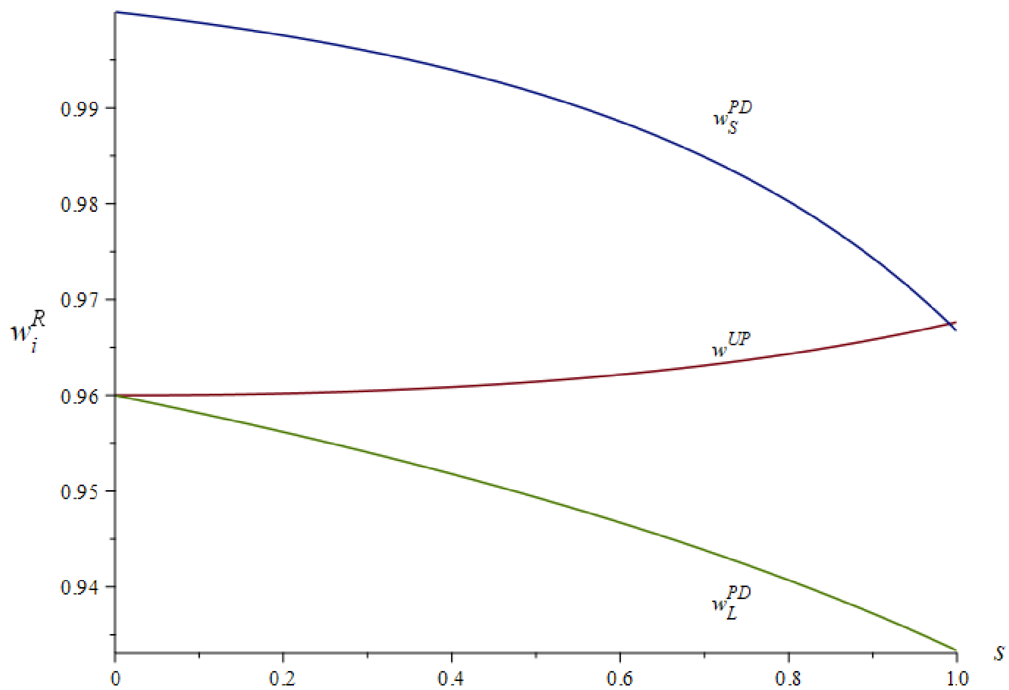

Figure 1: Wholesale prices.

the retail competition—the large retailer's investment incentives drop even further. The wholesale price is therefore increasing in s under uniform pricing.

For the large retailer, the gap in wholesale prices between uniform pricing and price discrimination increases in s. It is therefore obvious that price discrimination will benefit the large retailer. It also benefits consumers more as s increases, and is less profitable for the supplier. Further, the wholesale price towards the small retailer also decreases in s under price discrimination, but starts out at a higher level (the unconstrained $w^{NI} = 1$). By continuity, we still have the outcome that consumers are better off under uniform pricing, and that the supplier prefers price discrimination for s in the neighborhood of $s = 0$.

This begs for the question of whether there is a critical level of substitutability ($0 < s < 1$) such that consumers are better off with uniform pricing below this level, and the supplier is better off with uniform pricing above this level. A second question is whether consumers and suppliers always have opposing interests, or whether there could be an interval for s where supplier and consumer interests coincide.

We therefore propose the following:

Proposition 3 *There exist critical values* $s_c \in (0,1)$ *and* $s_u \in (0,1)$*, where* $s_c \lesseqqgtr s_u$*, such that (i) the supplier prefers uniform pricing if* $s \in (s_u, 1]$ *and price discrimination if* $s \in [0, s_u)$*, (ii) the consumers prefer price discrimination if* $s \in (s_c, 1]$ *and uniform pricing if* $s \in [0, s_c)$*. The supplier and the consumers have conflicting interests if* $s < min(s_c, s_u)$ *or* $s > max(s_c, s_u)$*.*

Proof. See Appendix A.5. ■

The outcome when the retailers are sufficiently close substitutes, $s > max(s_c, s_u)$, resembles the result found by Akgün and Chioveanu (2019) and O'Brien (2014) under perfect substitutes. The supplier want to commit to uniform pricing through, e.g., wholesale MFN clauses, when there is strong competition between the retailers. At the same time, it follows from Corollary 1 that the supplier prefers price discrimination if the retailers are unrelated. The opposite is true for the consumers, however. Hence, at the extremes ($s = 0$ and $s = 1$), the consumers and the supplier have opposite interests, and the incentives move in opposite directions.

There may, however, be an intermediate interval of s where the supplier and consumer interests coincide. From Proposition 3, we have the following corollary:

Corollary 2 *If* $s_c > s_u$*, both the consumers and the supplier prefer uniform pricing in the interval* $s \in (s_u, s_c)$*, whereas if* $s_c < s_u$*, both the consumers and the supplier prefer price discrimination in the interval* $s \in (s_c, s_u)$*.*

The results in Proposition 3 and Corollary 2 are illustrated in Figure 2.[12] The substitutability parameter, s, is on the horizontal axis. The figure shows, on the vertical axis, the differences in supplier profits (red line) and consumer surplus (blue line), respectively, under uniform pricing and price discrimination ($u^{UP} - u^{PD}$ and $CS^{UP} - CS^{PD}$). The supplier or consumers prefer uniform pricing when the vertical axis shows positive values, whereas price discrimination is preferred for negative values.

In Figure 2, we can see that when the retailers are unrelated ($s = 0$), the supplier prefers price discrimination and the consumers prefer uniform pricing (Corollary 1). This is the case for $s \in [0, s_u)$. As the retailers are closer substitutes, the incentives of the supplier

[12]Figure 2 is constructed with parameter values in the region $c \in (\max\{\underline{c}, \bar{c}_S^{PD}\}, \bar{c}_L^{UP}]$ for all s ($\gamma = 8, c = 1.025$). That is, the small retailer never invests in equilibrium. See Appendix A.1 for derivations of supplier profit and consumer surplus.

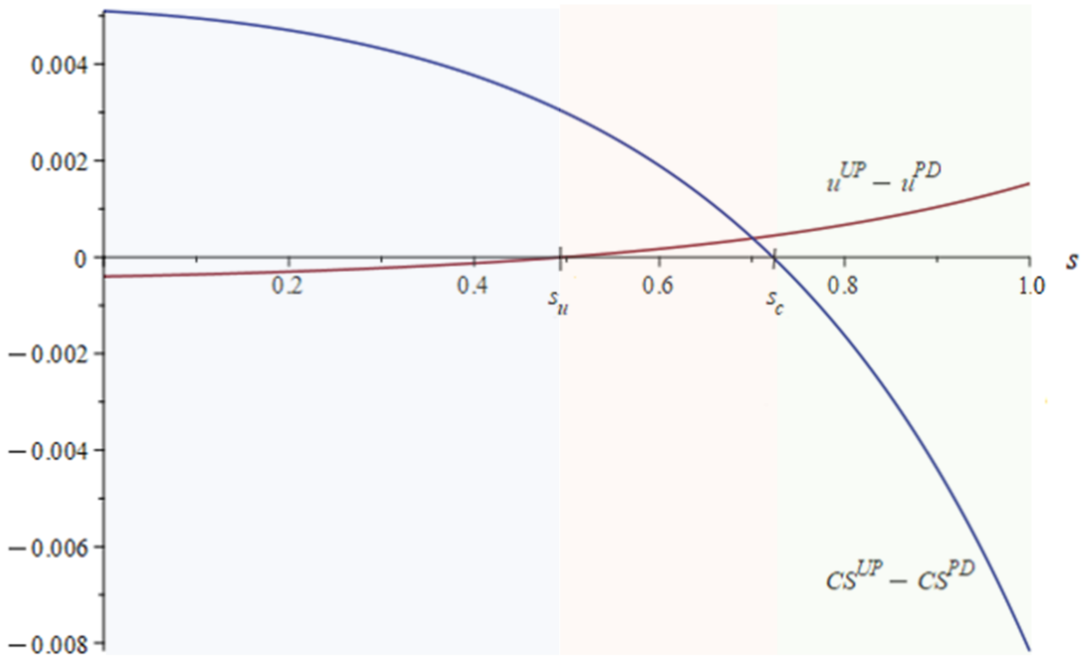

Figure 2: Consequences of uniform pricing on supplier profits and consumer surplus.

and consumers move in opposite directions. In the interval $s \in (s_u, s_c)$, both the supplier and the consumers are best off with uniform pricing.[13] However, as the retailers are closer substitutes—in the interval $s \in (s_c, 1]$—consumers will prefer price discrimination, whereas the supplier is better off with uniform pricing (Proposition 3). Who benefits from uniform pricing thus depends crucially on the degree of substitutability in the retail market.[14]

3 Extension: Inside options are binding for both retailers

Assumption 2 provides the sufficient conditions for when the large retailer invests and the small retailer does not invest under price discrimination. Let us now relax this assumption and consider the case where $c \in \left(\underline{c}, \overline{c}_S^{PD}\right)$, such that the inside option is binding for

[13]This is one potential outcome of Corollary 2. Under other parameter values, we cannot exclude the possibility that $s_c < s_u$, and we would have had the outcome that suppliers and consumers were all best off under price discrimination.

[14]The results on total welfare follow the same path as consumer surplus. However, we cannot provide any clear-cut results even at $s = 1$ as to whether uniform pricing or price discrimination yield the highest welfare. For details, see Appendix A.2.

both retailers. Appendix A.3 solves the retailers' maximization problem, and presents the equilibrium outcomes. When the retailers are unrelated ($s = 0$), the small retailer will also invest, such that—contrary to the outcome in the basic model—the small retailer obtains a lower wholesale price than the unconstrained wholesale price, although the price is nonetheless higher than the wholesale price the large retailer obtains. As in the case where the inside option is only binding for the large retailer, the uniform wholesale price is identical to the large retailer's price under price discrimination. The small retailer is therefore still better off with uniform pricing, $w^{PD-BI}_{L,s=0} = w^{UP}_{s=0} < w^{PD-BI}_{S,s=0} < w^{NI} = 1$. Both retailers' investment incentives increase with s under price discrimination.

In Appendix A.4.2, we derive the full condition for when the inside option is binding for the small retailer, and show that the small retailer will not invest if s is sufficiently large. This is because the small retailer is at this point better off free-riding on the large retailer's investments in inside options rather than making its own investments. The driving mechanism follows from Proposition 1: The closer rivals the retailers are, the more the supplier reduces the wholesale price to the small retailer. As a consequence, the closer substitutes are the retailers, the more profitable for the small retailer to not invest itself, but rather benefit from the lower price resulting from the large retailer's investments.

When $c \in \left(\underline{c}, \overline{c}^{PD}_S\right)$, the small retailer invests in the inside option. This only holds for sufficiently low values of s. As s becomes sufficiently large, such that $\max\{\underline{c}, \overline{c}^{PD}_S\} = \underline{c}$, the small retailer will no longer invest. We are then in the situation that $c \in (\underline{c}, \overline{c}^{UP}_L]$, where only the large retailer invests (as in the basic model). Since investment incentives are also lower for the large retailer when the small retailer does not invest, there is an upward shift in wholesale prices. This has consequences for supplier profit and consumer surplus as the small retailer goes from positive to no investments (i.e., when the inside option goes from binding to non-binding for the small retailer).

This case is depicted in Figure 3. To illustrate, we have set $\gamma = 4$ and $c = 1.025$. Figure 3 shows the differences in supplier profit and consumer surplus under each pricing regime. The inside option is a binding constraint for the small retailer in the interval $s \in [0, 0.252]$.[15] The supplier prefers to price discriminate, whereas the consumers are better off with uniform prices. For larger values of $s > 0.252$, the small retailer will

[15]By plotting for $\gamma = 4$ and $c = 1.025$ into the condition for when the inside option is binding for the small retailer (Equation (A.22) in Appendix A.4.2), and solving for s, we find that the small retailer will invest in the interval $s \in [0, 0.252]$.

not invest in equilibrium, and we obtain a picture similar to that in Figure 2, where the incentives eventually switch.

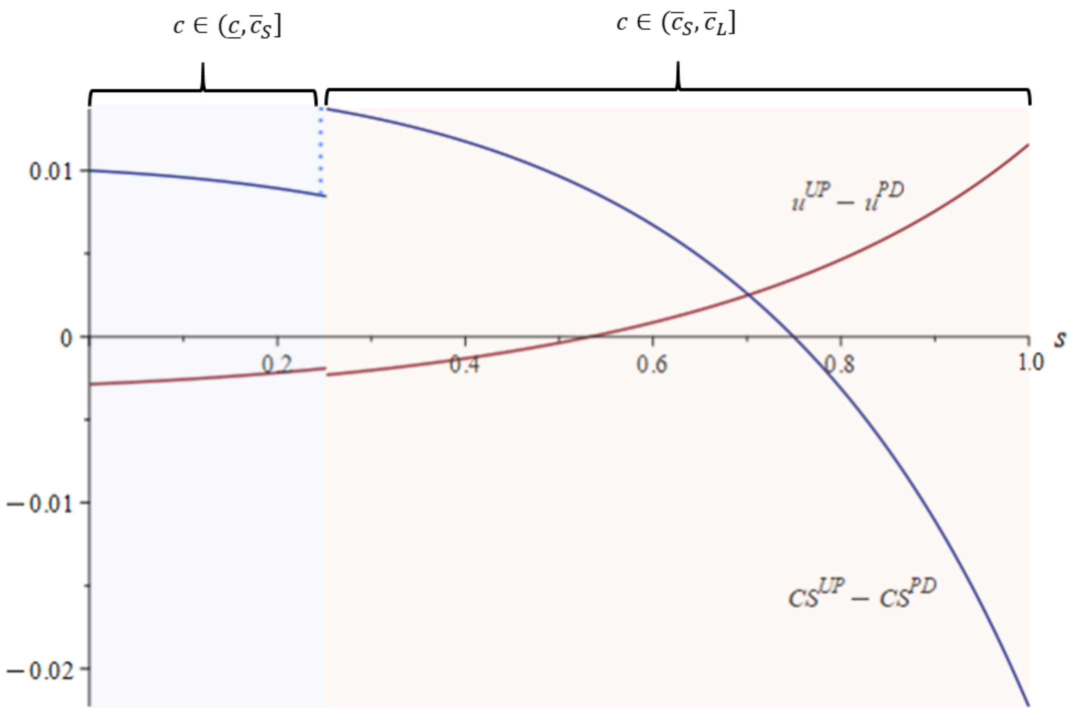

Figure 3: Consequences of uniform pricing on supplier profits and consumer surplus when S invests for sufficiently low s.

4 Concluding remarks

In this paper, we have shown how endogenous inside options may give rise to size-based wholesale price discrimination in favor of a large retailer, and that it is not clear-cut who benefits from uniform pricing and price discrimination, nor for which levels of substitutability among retailers. This stands in contrast to the clear-cut results given in the seminal papers by Katz (1987), O'Brien (2014), and Akgün and Chioveanu (2019). A large retailer clearly benefits from the supplier's ability to offer selective rebates, while smaller retailers are better off if the supplier is unable to price discriminate. More ambiguous is the effect on the supplier and the consumers, and we show that the degree of substitutability among the retailers is decisive. For low levels and high levels of substitutability, the supplier and the consumers have conflicting interests. However, for an intermediate level of substitutability, consumer and supplier interests can coincide.

The important distinction between inside and outside options is whether the investments take place before or after the supplier's decision on wholesale prices. This distinction may have a crucial impact on suppliers' incentives to price discriminate. In practice, however, retailers may improve their position towards suppliers through investments both ex ante negotiations with them, as well as through a credible threat of switching to an outside option ex post of the negotiations. Moreover, ex-ante investments may be necessary to create a credible threat of switching ex post. For example, in grocery retailing, where private labels can constitute an alternative source of supply, retailers will likely have to make significant investments prior to negotiations on wholesale prices with the brand suppliers for private labels to become a credible threat. If retailers decide to backward integrate and switch to a private label, they must likely undertake further investments.

In the book-publishing market, Amazon obtains low wholesale prices from suppliers (publishers) due to its size.[16] Gilbert (2015, p. 174) argues that an important part of Amazon's position is that it has a credible threat to backward integrate: "*Publishers have the additional concern that they will become an antiquated and redundant component of the book industry as Amazon increasingly deals directly with authors to supply books. Publishers fear that Amazon will 'disintermediate' the supply chain, replacing the traditional role of publishers to source and distribute content.*" This example illustrates that Amazon's credible threat comes from a combination of inside and outside options. Amazon undertakes investments into backward integration (Amazon Publishing), which provides proof of its ability to switch to an alternative source of supply.

In the multi-channel television market, a large player like Comcast, with its 23 million subscribers, has a size advantage over smaller rivals, such as Google Fiber and Cablevision, when it comes to using an alternative source of supply through backward integration into content programming. Doudchenko and Yurukoglu (2016) describe how Google Fiber emphasizes its significant disadvantage due to size-based wholesale price discrimination in favor of larger rivals such as Comcast. Also in this example, it seems reasonable that cable television providers need to make investments prior to negotiations on content wholesale

[16] Gilbert (2015, p. 173) writes "*Amazon could seek to exploit its power as a large buyer to obtain low wholesale prices, rebates, or other concessions from its suppliers, and a credible concern is that Amazon will continue to press its suppliers for better terms. Publishers complain that at Amazon, today's wholesale price is the starting point for tomorrow's negotiations.*"

prices in order to credibly threaten to—overnight—go to an alternative source of supply. Putting their threat into action would nonetheless involve further costs.

Finally, it is obviously a question of to what extent a supplier can commit to uniform pricing. In our model, a supplier that cannot commit to uniform pricing will provide a selective rebate to the large retailer. In several markets, we indeed observe that firms that control wholesale terms of trade may commit to non-discriminatory rules (e.g., wholesale MFNs). In other markets, we observe that firms are lobbying for non-discriminatory obligations, such as net-neutrality. As such, even if competition authorities do not actively pursue a non-discrimination policy, it is imaginable that the supplier could appeal to the competition law to signal that it is unable to price discriminate.

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A Appendix

A.1 Retailer profits, supplier profits, and consumer surplus

Stage 1 of the model is solved in Section 2.3. In this appendix, we demonstrate all results on retailer profits, supplier profits, and consumer surplus, under each price regime, uniform pricing (UP), and price discrimination (PD).

Uniform pricing: By inserting for w^{UP} from (13) into (9), we find the equilibrium quantities:

$$q^{UP} = \frac{\gamma(4-s)(2-c)}{\Omega}. \tag{A.1}$$

Recall that $\Omega = 8\left((\gamma-1)+\gamma\left(1-s\right)\right)+s\left(4+s\gamma\right)$. Substituting for Equations (13) and (A.1) into Equations (10) and (11), net profit under uniform pricing for the small and the large retailers, respectively, become

$$\pi_S^{UP} = \frac{\gamma^2(2-s)(4-s)^2(2-c)^2}{\Omega^2} \tag{A.2}$$

and

$$\pi_L^{UP} = \frac{2\gamma(2-s)(2-c)^2}{\Omega^2}. \tag{A.3}$$

For the supplier, the profit in each local market is given by $u^{UP} = 2w^{UP}q^{UP}$. Consumer surplus follows from inserting q^{UP} into (6). Since both retailers have the same level of output, consumer surplus is $CS^{UP} = 2\left(q^{UP}\right)^2$. Hence, by inserting the wholesale prices from Equation (13) and quantities from Equation (A.1) into Equations (5) and (6), we can calculate the supplier's profits and the consumer surplus in each local market, respectively:

$$u^{UP} = \frac{2\gamma(4-s)(2-c)(\gamma(4-s)^2c-8(2-s))}{\Omega^2} \tag{A.4}$$

and

$$CS^{UP} = \frac{2\gamma^2(4-s)^2(2-c)^2}{\Omega^2}. \tag{A.5}$$

Price discrimination: By inserting for w_S^{PD} and w_L^{PD} from (17) and (15), into (9), we find:

$$q_S^{PD} = \frac{1}{4-s} \text{ and } q_L^{PD} = \frac{\gamma(8-3s-(4-s)c)}{2(4-s)((2-s)\gamma-1)}, \tag{A.6}$$

such that by substituting Equations (15) and (A.6) into Equations (10) and (11), the net profit under price discrimination for the large and the small retailers, respectively, become

$$\pi_S^{PD} = \frac{2-s}{(4-s)^2} \tag{A.7}$$

and

$$\pi_L^{PD} = \frac{\gamma\left(4(2-c)-s(3-c)\right)^2}{2\left(4-s\right)^2\left((2-s)\gamma-1\right)}. \tag{A.8}$$

The supplier profit in each local market is $u^{PD} = w_S^{PD}q_S^{PD} + w_L^{PD}q_L^{PD}$. Consumer surplus follows from inserting q_S^{PD} and q_L^{PD} into (6). Hence, by inserting the wholesale prices from Equations (15) and (17), and the quantities from (A.6) into Equations (5) and (6), we can calculate the supplier's profits and the consumer surplus in each local market, respectively:

$$u^{PD} = \frac{8+(2-s)(4-s)\gamma\left[(4c(2-c)-(c+1)(3-c)s+4)\gamma-4(3-c)\right]}{2(4-s)^2((2-s)\gamma-1)^2} \tag{A.9}$$

and

$$\begin{aligned} CS^{PD} \quad = \quad & \frac{(2-s)[(s^2-32+80)\gamma^2+4-4\gamma(4-s)]-8\gamma s(3-s)}{8(4-s)^2((2-s)\gamma-1)^2} \\ & + \frac{(4-s)[(2-s)[c^2\gamma^2(4-s)-2c\gamma^2(8-s)]+4c\gamma s]}{8(4-s)^2((2-s)\gamma-1)^2}. \end{aligned} \tag{A.10}$$

A.2 Total welfare

Total welfare in each local market is the sum of the retailers' profits, consumer surplus, and the supplier's profits in each local market. Note that Equations (A.3) and (A.8) represent the net profit for the large retailer under uniform pricing and price discrimination, respectively. The large retailer is present in two local markets. We therefore divide net profit by two to find the per-outlet profits for L.

Uniform pricing: Using (A.2), (A.3), (A.4), and (A.5), total welfare under uniform pricing is hence

$$W^{UP} = 2\gamma(2-c)\left[\frac{\gamma(4-s)^2(c+2(3-s))+2c(2-s)^2+4s(16-3s)-80}{\Omega^2}\right]. \qquad \text{(A.11)}$$

Price discrimination: Using (A.7), (A.8), (A.9), and (A.10), total welfare under price discrimination is hence

$$\begin{aligned} W^{PD} &= (4-s)c\gamma\left[\frac{8(8-3s)-2c(4-s)-(2-s)\gamma((4-s)c+2(8-3s))}{8(4-s)^2((2-s)\gamma-1)^2}\right] \\ &\quad + \frac{(39s^2-224s+304((2-s)\gamma^2-2\gamma)-12s+56}{8(4-s)^2((2-s)\gamma-1)^2}. \qquad \text{(A.12)} \end{aligned}$$

Figure A.1 illustrates (for $\gamma = 8, c = 1.025$) that the difference in total welfare under each price regime ($W^{UP} - W^{PD}$) follows the same path as the difference in consumer surplus.

For $s = 0$, total welfare is highest under uniform pricing. Only the supplier prefers price discrimination. As s increases, price discrimination becomes more attractive from a total welfare perspective. We have been able to deliver clear-cut results on which regime is preferred for supplier profits and consumer surplus when $s = 1$ (see Proposition 3). This cannot be done for total welfare, however. In Figure A.1, constructed with the parameter values $\gamma = 8$ and $c = 1.025$, total welfare is highest under price discrimination at $s = 1$. This is not a general result. For other parameter values, uniform pricing might yield higher total welfare since investment competition becomes so tough when s is large that the investments might become too costly. As such, price discrimination might become socially harmful.

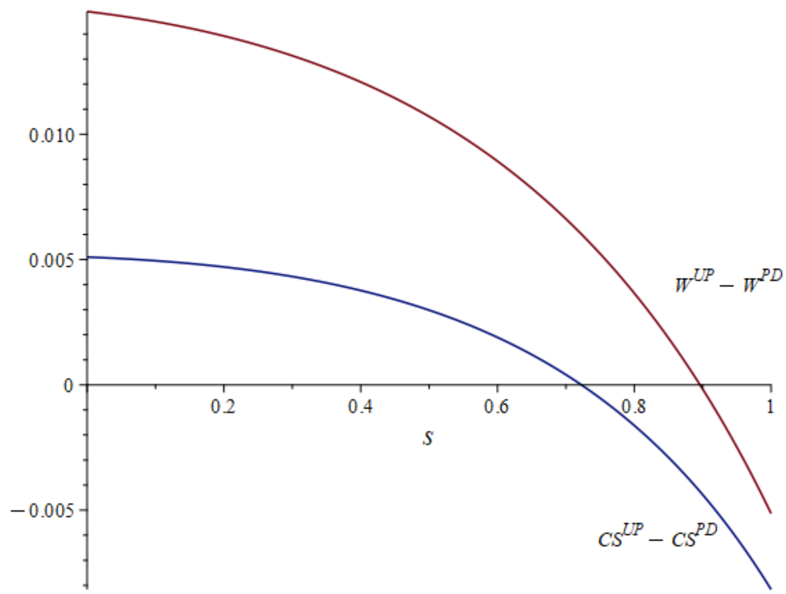


Figure A.1: Differences in total welfare follow differences in consumer surplus.

A.3 Inside option is binding for both retailers

We now assume that $\underline{c} < c < \bar{c}_S^{PD} < \bar{c}_L^{UP}$, such that both retailers invest (BI). The net profits for the small and large retailers, respectively, are given by Equations (10) and (11), where the cost of investment is given by (4). Each retailer i solves

$$\max_{x_i^{PD-BI}} \pi_i^{PD-BI} \text{ s.t. } w_i^{PD-BI} = c - x_i^{PD-BI},$$

which yield the retailers' response functions:[17]

$$x_S^{PD-BI}(x_L^{PD-BI}) = \frac{4\,(2-s)^2}{\gamma\,(4-s)^2\,(4-3s)^2 - 8\,(2-s)^3}\left[(2-c)\,(4-3s) - s x_L^{PD-BI}\right]$$

and

$$x_L^{PD-BI}(x_S^{PD-BI}) = \frac{8\,(2-s)^2}{\gamma\,(4-s)^2\,(4-3s)^2 - 16\,(2-s)^3}\left[(2-c)\,(4-3s) - s x_S^{PD-BI}\right].$$

We observe that the investments are strategic substitutes ($dx_i(x_j)/dx_j < 0$).

[17] Stability requires $|dx_L(x_S)/dx_S| < 1$. Since the best-response functions increase in s, the stability restriction is strictest at $s = 1$. Therefore, $|dx_L(x_S)/dx_S|_{s=1} = \frac{8}{9\gamma-16} < 1$ if $\gamma > \frac{8}{3}$ (Assumption 3).

By solving the reaction functions simultaneously, we obtain the investments by the small and large retailers, respectively, as given by

$$x_S^{PD-BI} = \frac{2-c}{4\gamma-1} + s\frac{(2-c)\gamma(4-s)(3s^2-12s+16)(4-3s)^2\gamma-4(9s^2-40+48)(2-s)^2}{(4\gamma-1)\Theta} \quad \text{(A.13)}$$

and

$$x_L^{PD-BI} = \frac{2-c}{2\gamma-1} + s\frac{(2-c)\gamma(4-s)(3s^2-12s+16)(4-3s)^2\gamma-16s(2-s)^2}{(2\gamma-1)\Theta}, \quad \text{(A.14)}$$

where $\Theta = (4-s)^3(4-3s)^3\gamma^2 - 24\gamma(4-s)(4-3s)(2-s)^3 + 32(2-s)^4$.

As in the case where the inside option is only binding for the large retailer, the investment level of the large retailer is identical under uniform pricing and price discrimination if $s = 0$ (the first term in Equation (13) is identical to (A.14) evaluated at $s = 0$), also when the inside option is binding for both retailers. From Equations (13) and (A.14), we have

$$x_L^{PD-BI} > x_L^{UP} \implies w_L^{PD-BI} < w^{UP} \text{ if } s > 0.$$

The wholesale price offered to the small retailer, however, is now lower than the unconstrained wholesale price, such that $w_S^{PD-BI} < w^{NI}$, when $s = 0$ (compare the first firm in Equations (13) and (A.13)). Since x_S^{PD-BI} increases in s, w_S^{PD-BI} is decreasing in s:

$$\frac{\partial x_S^{PD-BI}}{\partial s} > 0 \rightarrow \frac{\partial w_S^{PD-BI}}{\partial s} < 0.$$

Note also that the small retailer invests less than the large retailer in either price regime, and from Equations (13) and (A.13), we therefore have:

$$x_S^{PD-BI} < x_L^{UP} \implies w_S^{PD-BI} > w^{UP}.$$

Figure A.2 illustrates how the wholesale prices move when the inside option is binding for both retailers. The figure is illustrated with $\gamma = 4$ and $c = 1.025$ (as in Section 3; the inside option is therefore only binding in the region $s \in [0, 0.252]$).

By inserting the investments from (A.13) and (A.14) into the stage-three equilibrium

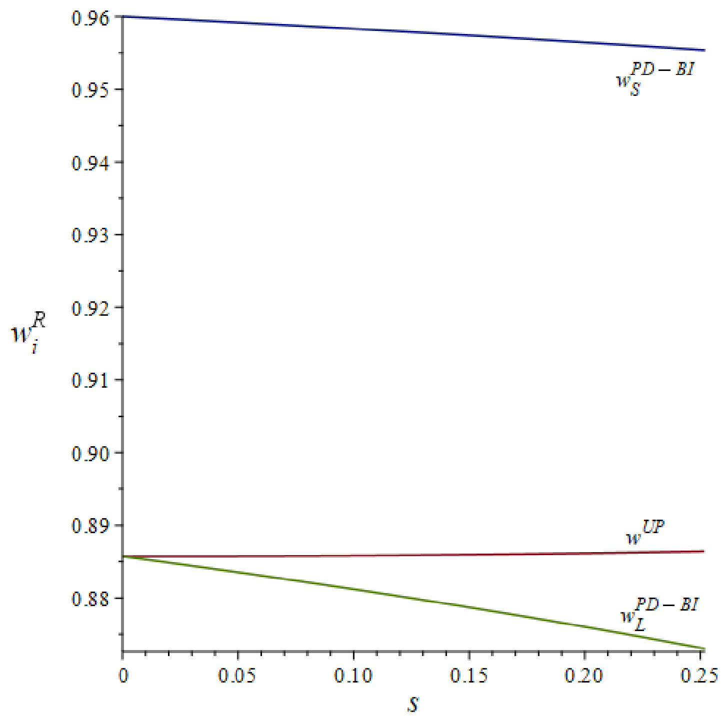


Figure A.2: Wholesale prices when the inside option is binding for both retailers.

quantities in (9), we obtain the following equilibrium outputs:

$$q_S^{PD-BI} = \frac{(4-s)(4-3s)(2-c)\gamma((4-s)(4-3s)^2\gamma - 8(2-s)^2)}{\Theta} \tag{A.15}$$

and

$$q_L^{PD-BI} = \frac{(4-s)(4-3s)(2-c)\gamma((4-s)(4-3s)^2\gamma - 4(2-s)^2)}{\Theta}. \tag{A.16}$$

Inserting the quantities from Equations (A.15) and (A.16) into (10) and (11), the net profits for the small and large retailer, respectively, are

$$\pi_S^{PD-BI} = \frac{\gamma(2-c)^2(2-s)((4-s)^2(4-3s)^2\gamma-8(2-s)^3)((4-s)(4-3s)^2\gamma-8(2-s)^2)^2}{\Theta^2} \tag{A.17}$$

and

$$\pi_L^{PD-BI} = \frac{2(2-c)^2(2-s)((4-s)^2(4-3s)^2\gamma-16(2-s)^3)((4-s)(4-3s)^2\gamma-4(2-s)^2)^2}{\Theta^2}. \tag{A.18}$$

By inserting the quantities from Equations (A.15) and (A.16) into (6) and (5), we can calculate the supplier's profits and the consumer surplus in each local market, respectively:

$$u^{PD-BI} = \frac{2\gamma(4-s)(4-3s)(2-c)\left[\Lambda\right]}{\Theta^2}, \tag{A.19}$$

where $\Lambda = c\gamma^3(4-s)^4(4-3s)^5 + 128\gamma(4-s)(4-3s)^2(2-s)^4 + 16c\gamma(10-3s)(4-3s)(4-s)(2-s)^4 - 12\gamma^2(2-s)^2(4-s)^2(4-3s)^3\left[c(4-s)+(4-3s)\right] - 384(2-s)^6$,

and

$$CS^{PD-BI} = \frac{2\gamma(4-s)^2(4-3s)^2(2-c)^2\left[\Upsilon\right]}{\Theta^2}, \tag{A.20}$$

where $\Upsilon = [(4-s)^2(4-3s)^4\gamma^2 + 4(10-s)(2-s)^4 - 12\gamma(4-s)(4-3s)^2(2-s)^2]$.

A.4 Conditions for binding inside options

A.4.1 The large retailer

The inside option is binding for the large retailer under uniform pricing as long as $\pi_L^{UP} - \pi_L^{NI} \geq 0$, where π_L^{UP} (Equation (A.3)) is the profit for the large retailer under uniform pricing if the inside option is binding, and $\pi_L^{NI} = 2\,(2-s)\left(q^{NI}\right)^2$ is the profit if the inside option is not binding, where q^{NI} is given by (7). We find that $\pi_L^{UP} - \pi_L^{NI} \geq 0$ if

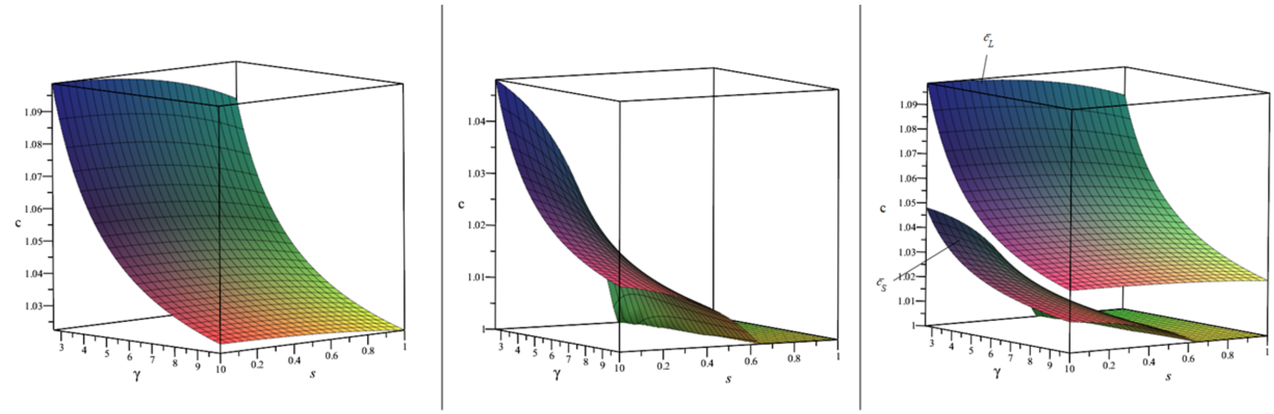
$$c \leq \bar{c}_L^{UP}(s) = 2 - \frac{\sqrt{\gamma\Omega}}{\gamma\,(4-s)}. \tag{A.21}$$

Since the large retailer has lower investment incentives under uniform pricing compared to under price discrimination, the condition above ensures that the large retailer invests under both regimes. Furthermore, under uniform pricing, the large retailer's investment decreases in s. A sufficient condition to ensure that the large retailer invests is thus to insert for $s = 1$, which is given by Assumption 2.

The constraint in Equation (A.21) is illustrated in panel (a) of Figure A.3. The large retailer will invest in the area below the graph, and is restricted downwards by $c > \underline{c} = 1$.

A.4.2 The small retailer

The inside option is never binding for the small retailer under price discrimination as long as $\pi_S^{PD} - \pi_S^{PD-BI} \geq 0$, where π_S^{PD} is the profit for the small retailer if the inside option is not binding and is given by (A.7), and π_S^{PD-BI} is the profit if the inside option is binding



(a) (b) (c)

Figure A.3: Constraints on c when the inside options are binding. Panel **(a)** displays $\bar{c}_L^{UP}$ (the constraint for when the inside option is binding for retailer L, cf. Equation (A.21)), panel **(b)** displays $\bar{c}_S^{PD}$ (the constraint for when the inside option is binding for retailer S, cf. Equation (A.22)), and panel **(c)** displays both constraints in the same diagram. L invests whenever the parameter values of γ, s, and c are below the plane in **(a)**, while S invests whenever the parameter values of γ, s, and c are below the plane in **(b)**.

for the small retailer and is given by (A.17), such that both retailers invest. We find that $\pi_S^{PD} - \pi_S^{PD-BI} \geq 0$ if

$$c \geq \bar{c}_S^{PD} = 2 - \sqrt{\frac{\left[(4-s)^3(4-3s)^3\gamma^2 - 24\gamma(4-s)(4-3s)(2-s)^3 + 32(2-s)^4\right]^2}{(4-s)^2\gamma[(4-s)^2(4-3s)^2\gamma - 8(2-s)^3]\left[(4-s)(4-3s)^2\gamma - 8(2-s)^2\right]^2}}. \quad \text{(A.22)}$$

The small retailer will not invest under uniform pricing, and instead free-ride on the large retailer's investments. Therefore, the inside option is never binding for the small retailer under uniform pricing. Since $\bar{c}_S^{PD}$ decreases in s (see panel (b) of Figure A.3), a sufficient condition to ensure that the small retailer does not invest is that $c \geq \max\left\{\underline{c}, \bar{c}_S^{PD}\right\}$ for $s = 0$, which is given by Assumption 2.

Another implication from Equation (A.22) is that the small retailer will only invest if $c \in (\underline{c}, \bar{c}_S^{PD}]$. This is the case for $s = 0$ and holds if s is sufficiently low. However, the small retailer will never invest in the inside option if s is sufficiently high. The constraint in Equation (A.22) is illustrated in panel (b) of Figure A.3. S will invest in the area below the graph, and is restricted downwards by $c > \underline{c} = 1$. From the figure, it becomes clear that the small retailer will only invest in the inside option if s is sufficiently low.

A.5 Proof Proposition 3

Using Equations (A.4) and (A.9), evaluated at $s = 1$, we find the following difference in supplier profits under each pricing regime:

$$
\begin{aligned}
(u^{UP} - u^{PD})|_{s=1} \quad = \quad & \frac{-243(c-1)^2\gamma^4 + 108(12c-13)(c-1)\gamma^3}{18(9\gamma-4)^2(\gamma-1)^2} \\
& + \frac{(168 - 36c(23c-22))\gamma^2 + (672c-576)\gamma - 128}{18(9\gamma-4)^2(\gamma-1)^2},
\end{aligned}
$$

which is positive for all $\gamma \in \left(\frac{8}{3}, \infty\right)$ in the relevant region $c \in (\underline{c}, \overline{c}_L]$.[18] That is, the supplier prefers uniform pricing at $s = 1$.

Using Equations (A.5) and (A.10), evaluated at $s = 1$, we find the following difference in consumer surplus under each pricing regime:

$$
(CS^{UP} - CS^{PD})|_{s=1} = \frac{[9(c-1)\gamma^2 + (26-24c)\gamma + 8]\,[-(135-63c)\gamma^2 + (118-48c)\gamma - 8]}{72(9\gamma-4)^2(\gamma-1)^2},
$$

which is negative for all $\gamma \in \left(\frac{8}{3}, \infty\right)$ in the relevant region $c \in (\underline{c}, \overline{c}_L]$.[19] Hence, consumers prefer price discrimination at $s = 1$.

From Corollary 1, we know that consumers are better off under uniform pricing, while the supplier is better off with price discrimination when retailers are unrelated ($s = 0$). Thus, by continuity, Proposition 3 follows. ■

[18] To see this, let us first consider $\gamma \to 8/3$. Evaluating Equation (A.21) for $\gamma \to 8/3$ yields $\overline{c}_L \to 1.0871$, and $u^{UP} - u^{PD} \to 0.2784 > 0$. If $\gamma \to \infty$, then $\overline{c}_L \to 1$, and $u^{UP} - u^{PD} = \frac{132\gamma^2+96\gamma-128}{18(9\gamma-4)^2(\gamma-1)^2} > 0$.

[19] To see this, let us first consider $\gamma \to 8/3$. Evaluating equation (A.21) for $\gamma \to 8/3$ yields $\overline{c}_L \to 1.0871$, and $CS^{UP} - CS^{PD} \to -0.050908 < 0$. If $\gamma \to \infty$, then $\overline{c}_L \to 1$, and $CS^{UP} - CS^{PD} = \frac{[2\gamma+8][-72\gamma^2+70\gamma-8]}{72(9\gamma-4)^2(\gamma-1)^2} < 0$ (the second square bracket in the numerator is clearly negative).