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Wholesale price discrimination: Innovation incentives and upstream competition

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Abstract

In intermediate good markets where there are alternative supply sources, wholesale price discrimination may enhance innovation incentives downstream. We consider a vertical chain where a dominant firm and a competitive fringe supply imperfect substitutes to duopoly retailers which carry both varieties. We show that a ban on price discrimination by the dominant supplier makes uniform pricing credible and reduces retailers' incentives to decrease the cost of acquiring the competitively supplied variety, leading to higher upstream profits and lower downstream welfare. Our analysis complements existing results by identifying a novel channel through which wholesale price discrimination can improve dynamic market efficiency.

1 | INTRODUCTION

The literature on price discrimination in intermediate good markets has focused mainly on situations where an upstream supplier is unconstrained or where downstream firms single source. However, downstream firms often have access to different suppliers, rather than being locked into a single upstream supplier. They also frequently multisource and do not allocate all of their volume to a single supplier on the basis of price alone even when upstream firms produce a relatively homogenous input for their product.[1] Moreover, if there is differentiation between the products of the upstream firms, then downstream firms may be purchasing from different suppliers to produce different varieties of their own products. Indeed, when the downstream activity is retailing, often multiple upstream differentiated suppliers' products are sold by each downstream competitor. For example, grocery stores commonly sell both branded products supplied by dominant manufacturers and differentiated varieties, including private labels.

This paper revisits the impact of price discrimination by a dominant supplier on downstream innovation incentives and welfare in a model where downstream firms resell both the supplier's product and a differentiated substitute available from a competitive fringe. We identify downstream firms' investment in reducing the cost of access to the differentiated alternative as a novel channel through which wholesale price discrimination may improve the dynamic efficiency of the market. A lower cost of accessing the fringe product may result from the retailer investing in own distribution assets specific to that product.[2]

If a monopoly supplier price discriminates against single-product downstream firms, the retailers which are more efficient in retailing pay a higher price because their demand for the supplier's product is less elastic (DeGraba, 1990; Katz, 1987). This 'distortion' effect (handicapping of more efficient firms) is also present in our setting with upstream competition and multiproduct retailers. However, we focus on an additional effect by distinguishing between downstream firms' relative efficiency in retailing and their relative efficiency in acquiring the differentiated substitute.

When the dominant supplier price discriminates, the retailer which is more efficient in acquiring the competitively supplied product may enjoy a lower wholesale price than its rival. This is because the retailer with a cost advantage in sourcing the differentiated substitute would have a more elastic demand for the dominant supplier's product when the retailers are equally efficient in retailing.

Starting from this additional effect, our study explores the impact of wholesale price discrimination on retailers' incentives to reduce the cost of acquiring the differentiated substitute. We consider a setting where two multiproduct retailers first invest in reducing the cost of access to the competitively supplied product. Then, the dominant supplier sets wholesale price(s) for its product. We compare two pricing regimes: Under price discrimination, wholesale prices may be differentiated across the two retailers, whereas under uniform pricing, both retailers pay the same price. In the final stage of our baseline model, the retailers compete in quantities for final consumers and profits are realized.

Our analysis shows that wholesale price discrimination by the dominant supplier fosters the retailers' incentives to invest in reducing the marginal cost of acquiring the differentiated variety. Under price discrimination, a relative advantage in sourcing the competitively supplied product triggers a (larger) wholesale price reduction and so the retailers invest more than under uniform pricing to lower the cost of acquiring the differentiated alternative. Moreover, when the retailers share the same downstream retailing technology and invest in improving own access to the imperfect substitute product, wholesale price discrimination boosts downstream welfare, calculated as the sum of consumer welfare and downstream profits, compared to a uniform pricing regime.

The dynamic efficiency of wholesale price discrimination was first analyzed by DeGraba (1990). In his model, an upstream monopoly supplies an input to two downstream firms which may differ in their production costs. These downstream production costs are conceptually related to our retailing costs. Thus, from the perspective of our model, DeGraba (1990) focuses on downstream firms' incentives to reduce retailing costs and shows that wholesale price discrimination lowers a firm's benefit from investment. This is the case because having a lower cost leads to a higher input price. He also shows that the underinvestment in cost reduction due to price discrimination results in higher marginal costs and, under reasonable conditions, lower welfare than under a credible commitment to uniform pricing.[3]

In general, when downstream firms may differ in both retailing cost and the cost of sourcing the differentiated alternative, and they can invest to reduce both these costs, the impact of wholesale price discrimination on innovation and welfare is determined by a trade-off between the (stifling) effect in DeGraba (1990) and the (fostering) effect highlighted in our analysis. By allowing for upstream competition and retailers which source multiple differentiated varieties, our analysis points to a wider principle whereby intermediate product price discrimination decreases (increases) multiproduct retailers' incentives to make investments that boost (lower) their demand for the dominant supplier's product.

Analyzing the static efficiency of third-degree price discrimination in intermediate product markets, Katz (1987) considers a setting where an upstream monopolist supplies an input to independent downstream duopoly markets. In each market, one firm poses a threat of backward integration, so the upstream monopolist has incentives to price discriminate. If there is no integration in equilibrium regardless of the pricing regimes, then input price discrimination always leads to lower output and welfare and, under reasonable conditions, to higher prices to all buyers. However, if uniform pricing leads to integration but price discrimination does not, then the latter may prevent socially inefficient integration and raise welfare.[4]

Price discrimination allows the upstream monopolist to appropriate some of the benefits of a distributor's superior technology, but it results in the allocation of a higher share of downstream output to less efficient retailers (compared to the uniform pricing regime) and so it harms total welfare when it does not change total final output. Yoshida (2000) considers more general downstream technologies which allow price discrimination to alter total final output and shows that, although the impact of input price discrimination on final good output and welfare is in general ambiguous, the practice harms total welfare if it results in higher final good output. Valletti (2003) revisits Yoshida's model and, by introducing a decomposition of the upstream monopolist's profit into a part that depends on the average input price and another part which depends on the distribution of input prices, shows that under reasonable conditions the practice harms both total welfare and consumer surplus.[5]

Inderst and Valletti (2009) explore price discrimination by an upstream monopolist when two single-product downstream firms have access to a perfect substitute input once they pay a fixed cost (e.g., if they integrate backward).[6] They analyze retailers' incentives to invest in reducing downstream marginal costs in this setting.[7] In contrast, we consider multiproduct downstream competitors, which always distribute both the dominant supplier's product and a competitively supplied differentiated variety, and focus on retailers' incentives to invest in the cost of access to the differentiated alternative.

In the context of our model, the results that Inderst and Valletti (2009) obtain for a general demand specification imply that one of the downstream competitors invests more in retailing cost reduction under wholesale price discrimination than under uniform pricing. For linear demand and quadratic investment costs, Inderst and Valletti (2009) also show that both downstream firms invest more under discriminatory pricing when the fixed cost of switching to the alternative input is low. In our model, although the equilibrium depends on the pricing regime, it is symmetric both under price discrimination and under uniform pricing. For tractability, we also focus on linear demand and quadratic investment costs and show that wholesale price discrimination always results in a larger investment in reducing the cost of acquiring the competitively supplied variety. This is because, under price discrimination, a dominant supplier has an incentive to offer a better deal to a retailer which is more efficient in substituting away from its product.

In European case law, a dominant firm applying dissimilar conditions to equivalent transactions with other trading parties may be found guilty of abusing its dominant position even when discrimination serves to meet competition.[8] For example, Irish Sugar was found guilty of granting special rebates to certain retailers established along the border with Northern Ireland to compete with cheap imports of sugar from the region repackaged for retail sale. The European Court of First Instance has ruled that 'confronting' competition from sugar imported from Northern Ireland is not an objective economic justification for border rebates as these were aimed at preventing such competition from developing in the rest of Ireland.[9] This approach assumes that allowing the dominant firm to credibly commit to uniform pricing will have no impact on the costs of alternative supply. However, if a retailer knew that by improving access to alternative product it could access also the dominant firms' product at lower prices than its rivals, it would put more effort into reducing the cost of alternative supply. Thus, as our analysis confirms, the efficiency of alternative supply may be higher when the dominant supplier cannot commit to uniform pricing.

2 | THE MODEL

Consider a vertically related industry. An upstream dominant firm (M) and a competitive fringe supply differentiated (intermediate) products U and S, respectively, to a downstream market. The upstream marginal costs of production are constant and normalized to zero. Downstream, two independent retailers A and B both resell the two differentiated varieties and compete in quantities for final consumers. One unit of the wholesale product corresponds to one unit of the retail good. We consider downstream retailers, but the model could be interpreted alternatively as a production chain where each downstream firm produces the same two differentiated products. One of the downstream goods is produced from one unit of the dominant upstream supplier's product, while the other from one unit of competitively supplied input.

In the retail product market, inverse demand functions for the two varieties, U and S, are

$$P^U(q^U, q^S) = \alpha - \beta q^U - \gamma q^S \quad \text{and} \quad P^S(q^U, q^S) = \alpha - \beta q^S - \gamma q^U, \tag{1}$$

where $q^l = q_A^l + q_B^l$ denotes the total quantity of product $l = U, S$, and $\alpha, \beta, \gamma > 0$. γ captures the degree of product differentiation. $\beta > \gamma$, that is, an increase in the supply of S (U) has a greater impact on the price of S (U) than on the price of U (S). The representative consumer's quadratic utility function which corresponds to (1) is presented in the appendix.[10]

Under a price discrimination regime, the dominant supplier may charge differentiated prices (i.e., $w_A \neq w_B$), while under a uniform pricing regime, M must charge the same wholesale price to both retailers (i.e., $w_A = w_B$).[11] The latter situation would apply in the presence of a ban on price discrimination. A and B's constant marginal costs of acquiring the competitively supplied variety are c_A and c_B, respectively, where $c_i = c - m_i$ (for $c > 0$). Retailer $i = A, B$ can achieve cost reduction m_i by spending $\Gamma(m_i) = m_i^2/2$. The downstream firms, A and B, face marginal retailing costs, d_A and d_B, respectively. In the context of a production chain, these could be regarded as downstream operation or production costs which apply to both products.[12] We explore the dynamic efficiency of wholesale price discrimination, by focusing on retailers' incentives to invest in the reduction of c_i.

We analyze a three-stage model where the retailers first invest simultaneously to reduce the cost of access to S, then, the dominant supplier sets either a uniform price or discriminatory wholesale prices, depending on the pricing regime, and finally the retailers compete in quantities for final consumers. We solve by backward induction for the subgame perfect Nash equilibria. We start by analyzing the third stage of the game below. Section 3 explores the dominant supplier's choice of wholesale prices under uniform pricing and under price discrimination, while Section 4 analyzes retailers' investments in cost reduction. Section 5 discusses the robustness of the results and presents final conclusions. All proofs missing from the text are relegated to the appendix.

2.1 | Competition in the final product market

In the final stage of the game, retailers compete by simultaneously choosing quantities of the two varieties. Retailer i (for $i = A, B$) chooses q_i^U and q_i^S to maximize its profit

$$\pi_i = (P^U - w_i - d_i)q_i^U + (P^S - c_i - d_i)q_i^S,$$

where P^U and P^S are given by (1). The first-order conditions of retailer i's profit maximization problem require that $\partial\pi_i/\partial q_i^U = 0$ and $\partial\pi_i/\partial q_i^S = 0$.

The unique equilibrium quantities for given wholesale prices and marginal costs are

$$q_i^U = \frac{\beta(2a_U^i - a_U^j) - \gamma(2a_S^i - a_S^j)}{3(\beta^2 - \gamma^2)} \quad \text{and} \quad q_i^S = \frac{\beta(2a_S^i - a_S^j) - \gamma(2a_U^i - a_U^j)}{3(\beta^2 - \gamma^2)},$$

for $i,j \in \{A, B\}$ and $i \neq j$, where $a_U^i = \alpha - w_i - d_i$ and $a_S^i = \alpha - c_i - d_i$.

In contrast to existing work, our analysis focuses on the impact of wholesale price discrimination on downstream firms' incentives to reduce the cost of acquiring the differentiated alternative, that is, c_i. Alternatively, downstream firms could invest in reducing operation or retailing costs, d_i. In our model, the differentiated alternative is supplied by a competitive fringe, and so it can be treated parametrically as part of the downstream demand function. Therefore, if the retailers invest to reduce retailing costs, the results in DeGraba (1990)—where the upstream supplier is an unconstrained monopolist—carry over unchanged to our framework. Inderst and Valletti (2009) consider a model where an alternative supply is a perfect substitute of the upstream firm's product. In their analysis, marginal cost reductions apply to both the dominant and alternative supply, although in equilibrium downstream firms do not use the latter. The corresponding cost reductions in our framework would be those that affect the retailing costs (d_i).

3 | WHOLESALE PRICES

In the second stage, the upstream supplier M sets the wholesale prices, w_A and w_B to maximize its profit

$$\pi_M = w_A q_A^U + w_B q_B^U.$$

Under wholesale price discrimination, the dominant supplier can set $w_A \neq w_B$. The equilibrium prices for given marginal costs are

$$w_A = \frac{-\gamma\alpha + \beta(\alpha - d_A) + \gamma(d_A + c_A)}{2\beta} \quad \text{and} \quad w_B = \frac{-\gamma\alpha + \beta(\alpha - d_B) + \gamma(d_B + c_B)}{2\beta}. \tag{2}$$

So, when the dominant supplier price discriminates,

$$w_B - w_A = \frac{(\beta - \gamma)(d_A - d_B) + \gamma(c_B - c_A)}{2\beta}. \tag{3}$$

If retailers are equally efficient in acquiring the competitively supplied product (i.e., if $c_B = c_A$), then the sign of $(w_B - w_A)$ is given by the sign of $(d_A - d_B)$. In particular, if retailer A is more efficient in retailing (i.e., $d_A < d_B$), then it will pay a relatively higher price $w_A > w_B$.

A similar exercise illustrates how discriminatory wholesale prices are affected by differences in retailers' costs of sourcing the competitively supplied product. If there are no differences in retailing efficiency (so $d_A = d_B$), the sign of $(w_B - w_A)$ is given by the sign of $(c_B - c_A)$ and so, if retailer A is more efficient in acquiring product S (i.e., $c_A < c_B$), then it will be offered a relatively better deal by a price-discriminating dominant supplier (i.e., $w_A < w_B$).

Intuitively, if the dominant supplier price discriminates, a retailer which is more efficient in acquiring the competitively supplied product has more incentives to divert sales of the dominant supplier's product to the differentiated alternative. Then, to prevent a retailer who is more efficient in sourcing S from diverting units, the supplier needs to charge it a lower wholesale price. In general, $(w_B - w_A)$ increases in $(d_A - d_B)$ and decreases in $(c_A - c_B)$. The larger the advantage of A in distribution, the higher the wholesale price it has to pay—discrimination favors the less efficient in distribution—and the larger the advantage of A in access to the differentiated alternative, the lower the wholesale price it has to pay—discrimination favors the retailer with a better access to the alternative.

Under uniform pricing, the supplier sets $w_A = w_B$ and the equilibrium wholesale price for given marginal costs is

$$w_U = \frac{-2\gamma\alpha + \beta(2\alpha - d_A - d_B) + \gamma(d_A + c_A + d_B + c_B)}{4\beta}. \tag{4}$$

Using (2) and (4), the changes in wholesale prices when the dominant supplier price discriminates are given by

$$w_A - w_U = \frac{(\beta - \gamma)(d_B - d_A) + \gamma(c_A - c_B)}{4\beta} \quad \text{and} \quad w_B - w_U = \frac{(\beta - \gamma)(d_A - d_B) + \gamma(c_B - c_A)}{4\beta}.$$

We summarize these preliminary findings below.

Lemma 1 *(a) If retailers are equally efficient in acquiring the competitively supplied product ($c_A = c_B$) and A is more efficient in retailing ($d_A < d_B$), under price discrimination A (B) pays a higher (lower) wholesale price than under uniform pricing, that is, $w_A > w_U > w_B$. (b) If retailers are equally efficient in retailing ($d_A = d_B$), but A is more efficient in acquiring the competitive product ($c_A < c_B$), A (B) pays a lower (higher) wholesale price with price discrimination than with uniform pricing, that is, $w_A < w_U < w_B$.*

Part (a) of Lemma 1 corresponds to existing results in the literature. By considering a differentiated alternative at the upstream level, part (b) identifies a novel efficiency channel. If the dominant supplier can discriminate between retailers, it offers a lower wholesale price to the downstream firm which is more efficient in acquiring the competitively supplied variety to prevent it from substituting away from its product. So, a retailer which can acquire the differentiated alternative at a lower cost is better off under wholesale price discrimination than under uniform pricing.

In the next section, we focus on this alternative efficiency channel from a dynamic perspective. We assume that the retailing costs are zero ($d_i = 0$, $i = A, B$) and analyze how the pricing regime affects retailers' investment in reducing the cost of acquiring product S.[13] While this is not without loss of generality, it allows us to derive closed form solutions, compare market outcomes under discriminatory and uniform pricing regimes, and highlight the corresponding effects.

4 | COST-REDUCTION INVESTMENTS

We write the retailers' profits in the reduced-form investment games under discriminatory and uniform pricing as functions of their cost-reduction choices, by substituting into (1) the second-stage results presented in (2) and (4) and deducting the quadratic cost-reduction investments.

Under wholesale price discrimination, retailer i chooses a cost-reduction level m_i to maximize its profit given by

$$\pi_i^{PD} = \frac{\beta\alpha(\beta\alpha - 2\gamma\Delta_i) + (4\beta^2 - 3\gamma^2)(\Delta_i)^2}{36\beta(\beta^2 - \gamma^2)} - \frac{(m_i)^2}{2}, \tag{5}$$

where $\Delta_i = (\alpha - c + 2m_i - m_j)$.

Using the first-order conditions for the profit maximization ($\partial \pi_i^{PD}/\partial m_i = 0,\ i = A, B$), the equilibrium cost-reduction levels are

$$m_i^{PD} = m_j^{PD} = \frac{\gamma\beta\alpha - (4\beta^2 - 3\gamma^2)(\alpha - c)}{3(1 - 3\beta)(\beta^2 - \gamma^2) + \beta^2} \equiv m^{PD}. \tag{6}$$

Substituting (6) into (2), the equilibrium wholesale prices under price discrimination are

$$w_A^{PD} = w_B^{PD} = \frac{(\beta^2 - \gamma^2)[(4 - 9\beta)\alpha + 9\gamma(\alpha - c)]}{2[3(1 - 3\beta)(\beta^2 - \gamma^2) + \beta^2]} \equiv w^{PD}. \tag{7}$$

Due to symmetry, the retailers choose the same cost-reduction level and pay the same wholesale price in a given pricing regime. However, as under price discrimination, the dominant supplier is unable to commit to a common price, the retailers' incentives to invest in reducing the cost of acquiring the competitive supplied product are different from those under uniform pricing. A given unilateral reduction in a retailer's cost of acquiring the competitively supplied input leads to a larger discount from a price-discriminating dominant supplier than from a nondiscriminating supplier.

Under uniform pricing, retailer i chooses its cost-reduction level m_i to maximize

$$\pi_i^{UP} = \frac{(2\beta\alpha - \gamma\bar{\Delta}_i)^2 + 16(\beta^2 - \gamma^2)(\Delta_i)^2}{144\beta(\beta^2 - \gamma^2)} - \frac{(m_i)^2}{2},$$

where $\bar{\Delta}_i = 2\alpha - 2c + 7m_i - 5m_j$ and Δ_i is defined below (5).

Solving the system of first-order conditions for the profit maximization ($\partial \pi_i^{UP}/\partial m_i = 0,\ i = A, B$), the symmetric equilibrium cost-reduction level under uniform pricing is

$$m^{UP} = \frac{7\gamma\beta\alpha - (16\beta^2 - 9\gamma^2)(\alpha - c)}{9(1 - 4\beta)(\beta^2 - \gamma^2) + 7\beta^2}. \tag{8}$$

Substituting (8) into (4), we obtain the equilibrium wholesale price under uniform pricing

$$w^{UP} = \frac{2(\beta^2 - \gamma^2)[(4 - 9\beta)\alpha + 9\gamma(\alpha - c)]}{9(1 - 4\beta)(\beta^2 - \gamma^2) + 7\beta^2}. \tag{9}$$

If the profit functions, π_i^{PD} and π_i^{UP}, are strictly concave and the best response mapping is a contraction, the reduced-form game has a unique equilibrium under the two pricing regimes. The required conditions are presented in the appendix. The most restrictive one is the strict concavity of π_i^{UP} which underlies the sufficient condition below.[14]

Condition 1

$$3(\beta^2 - \gamma^2)(5 - 24\beta) + 49\beta^2 < 0.$$

We are now ready to compare the market outcomes under wholesale price discrimination and uniform pricing.

Proposition 1 *Suppose Condition 1 holds. Compared to uniform pricing, wholesale price discrimination results in (a) a larger reduction in the cost of acquiring the competitively supplied product, (b) lower wholesale prices, (c) a smaller quantity of dominant supplier's product, (d) a larger quantity of the competitively supplied product, and (e) lower retail prices for both varieties.*

Both retailers invest more in cost reduction under wholesale price discrimination than under uniform pricing. With price discrimination, the wholesale price difference ($w_B - w_A$) increases in the cost advantage for acquiring the substitute product ($c_B - c_A$). If retailer i can source S at a lower cost than its rival, it has a stronger incentive than its competitor to substitute sales of U with sales of S. Therefore, the supplier offers retailer i a relatively better wholesale price to mitigate this incentive. In contrast, with uniform pricing, the retailer shares the benefit of the additional cost reduction with its rival, so the incentive to invest in cost reduction is lower.

Our investment analysis considers marginal cost reductions associated with the competitively supplied product only. Inderst and Valletti (2009) focus mainly on cost reductions that apply to both the dominant supplier's product and a perfect substitute. In their model, the constraint on the dominant firm's pricing works through single-product retailers' threat to switch all of their purchases from the dominant supplier to alternative supply sources which are perfect substitutes. When the costs of downstream firms differ, the uniform wholesale price does not depend on the cost of the less efficient firm and it is equal to the discriminatory wholesale price offered to the more efficient firm. Therefore, with uniform pricing, the incentives to reduce the wholesale price play no role in the cost-reduction choice of one of the two downstream firms. In contrast, with price discrimination, the wholesale price offered to the less efficient firm depends on its cost so that the incentives to reduce the wholesale price do play a role in the cost-reduction choices of both firms. So, a change from uniform to discriminatory pricing increases the equilibrium investment of the downstream firm that invests less than its rival under the former regime. The change in the equilibrium investment of the other downstream firm is ambiguous.

In an extension where the downstream firms can invest to reduce the cost of the alternative supply after bypassing the dominant supplier, Inderst and Valletti (2009) show that, with uniform pricing, investment equilibrium is still asymmetric. In an example with linear demand and quadratic investment costs, they show that, if the fixed cost of switching to the alternative source of supply is low, both firms invest more with discriminatory pricing. Intuitively, with a low fixed cost, the equilibrium investments of the two firms under uniform pricing differ less, so the negative impact of strategic substitution on the more efficient firm's investment is smaller and likely to be offset. Our results complement theirs by showing that price discrimination can improve dynamic efficiency even in a setting where both firms' cost-reduction investments are affected by the incentives to reduce the wholesale price.

Proposition 2 *Suppose Condition 1 holds. Total welfare and the dominant supplier's profit are lower, while downstream welfare, calculated as the sum of downstream profits and consumer surplus, is higher under wholesale price discrimination than under uniform pricing.*

Price discrimination has a negative impact on the upstream supplier's profit. With discriminatory pricing, the retailers invest more and achieve lower marginal costs of acquiring the competitively supplied variety. This decreases both the wholesale price and the sales volume of the dominant supplier's product. Discriminatory pricing also harms total welfare. However, it boosts downstream welfare (i.e., the sum of retailers' profits and consumer surplus), as final consumers benefit from lower retail prices and downstream firms from lower costs of acquiring the competitively supplied product.

5 | CONCLUSIONS

This paper studies wholesale price discrimination in a setting where an upstream dominant supplier and a competitive fringe supply differentiated varieties to two multiproduct downstream retailers. It focuses on the impact of price discrimination by the dominant supplier on the dynamic efficiency of the market and shows that the practice improves multiproduct retailers' incentives to reduce the cost of acquiring the competitively supplied product.

Regardless of the pricing regime, in our setting there is no price discrimination in equilibrium and the multiproduct retailers offer both varieties. Nevertheless, if the dominant supplier cannot commit to charging uniform wholesale prices, the retailers choose a technology with a lower cost of acquiring the competitively supplied product. Discriminatory pricing provides a lower price to the retailer which can access the differentiated alternative at a lower cost. As a result, investment in reducing the cost of access to the competitively supplied variety and downstream welfare are higher under discriminatory than under uniform pricing. We conduct our analysis from a competition policy perspective and so formulate a model where retailers operate in the same downstream market. However, it can be shown that our central finding is not dependent on competition between retailers and carries over to a setting where the retailers operate in separate downstream markets.

Our study identifies situations where discriminatory pricing improves the dynamic efficiency of the market and complements existing work. In particular, combined with the results in DeGraba (1990), our findings point to a wider principle that governs the dynamic efficiency of wholesale price discrimination by a dominant supplier. The practice fosters downstream investments that decrease multiproduct retailers' demand for the dominant supplier's product, while it stifles downstream investments that increase multiproduct retailers' demand for the dominant supplier's product. In an example where the retailers could lower both the retailing cost and the cost of accessing the competitively supplied product by making a single investment, we were able to show that the net effect of price discrimination on downstream investment incentives can run in either direction depending on which cost is more affected. In general, the overall impact of wholesale price discrimination on innovation and welfare depends on the trade-off between different effects and therefore on the specific market conditions.

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END NOTES

[1] For example, requested order lead times, delivery sizes, third-party risks, and payments terms can introduce an element of horizontal differentiation from the perspective of buyers.

[2] A retailer may need additional warehouse space to take larger deliveries from the fringe suppliers and distribute to its own stores, for instance. The investment would bring no benefits in handling the dominant supplier's product whenever that product is delivered to its individual stores in smaller quantities by the supplier or an independent wholesaler who carries the dominant supplier's product.

[3] The impact of discriminatory pricing on innovation incentives has also been studied by Choi (1995) in an international trade context and by Choi and Kim (2010) in relation to net neutrality regulation.

[4] Katz (1987) shows that if only one pricing regime leads to integration this occurs under uniform pricing.

[5] Herweg and Müller (2012) endogenize downstream industry structure and show that input price discrimination fosters entry which often improves welfare, although entry may also harm welfare by creating severe inefficiency in production.

[6] Unlike Katz (1987), where the threat of backward integration is only credible for the largest buyer, in Inderst and Valletti (2009) both retailers can credibly bypass the monopolist supplier.

[7] As in our discussion of DeGraba (1990), in the context of our model, this would be a reduction in downstream retailing costs as the cost reduction applies to all sales of the downstream firm, independently of the upstream product choice. In Inderst and Valletti (2009), this reduction would apply to both the upstream monopolist's product and to the alternative supply when the fixed cost of access is paid, but in equilibrium downstream firms use only one supply source.

[8] Article 102 of Treaty on the Functioning of the European Union provides the ground for competition agencies to bring cases against manufacturers who charge discriminatory prices to resellers.

[9] See the discussion in paragraphs 173-193 of the judgment of the Court of First Instance in case T-228/97 Irish Sugar plc versus Commission of the European Communities available at http://curia.europa.eu/juris.

[10] It can be shown that our qualitative results are robust in a setting where $P^U(q^U, q^S) = \alpha_U - \beta_U q^U - \gamma q^S$ and $P^S(q^U, q^S) = \alpha_S - \beta_S q^S - \gamma q^U$ with α_k, β_k, $\gamma > 0$, and $\beta_k > \gamma$ for $k = U, S$. However, for expositional simplicity, we focus on $\alpha_U = \alpha_S$ and $\beta_U = \beta_S$.

[11] Our analysis focuses on linear wholesale prices. A different stream of literature explores discriminatory nonlinear prices. See, for instance, Inderst and Shaffer (2009), the two-part tariff analysis in Arya and Mittendorf (2010), and Herweg and Müller (2014).

[12] When downstream firms are producers these can also be interpreted as the marginal cost of converting one unit of upstream input into one unit of downstream product.

[13] We focus on the cost of acquiring the differentiated upstream variety, but our results apply more generally to any investment that reduces a cost specific to that variety (or increases the intercept of the corresponding linear inverse demand).

[14] These are based on the standard contraction approach, see Vives (2001) [Chapter 2]. Strict concavity of the profit functions guarantees that retailer i's best response is unique and given by a function. If the best response mapping is a contraction, then the reduced-form game has a unique equilibrium. In our model, due to ex ante symmetry, the unique equilibrium for a given pricing regime is symmetric.

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APPENDIX A

Conditions for the existence and uniqueness of equilibrium in the reduced-form investment game

1. Wholesale price discrimination.

The retailers' profits are strictly concave iff, for $i = A, B$,

$$\frac{\partial^2 \pi_i^{PD}}{\partial m_i^2} < 0 \Leftrightarrow \frac{3(\beta^2 - \gamma^2)(2 - 3\beta) + 2\beta^2}{9\beta(\beta^2 - \gamma^2)} \equiv \Phi_1 < 0.$$

Note that Condition 1 is a sufficient condition for $\Phi_1 < 0$.

There is a unique investment equilibrium if, for $i, j = A, B$ and $i \neq j$,

$$\frac{\partial^2 \pi_i^{PD}}{\partial m_i^2} + \frac{\partial^2 \pi_i^{PD}}{\partial m_i \partial m_j} < 0 \Leftrightarrow \frac{3(\beta^2 - \gamma^2)(1 - 3\beta) + \beta^2}{9\beta(\beta^2 - \gamma^2)} \equiv \Phi_2 < 0.$$

Note that $\Phi_1 < 0$ is a sufficient condition for $\Phi_2 < 0$.

2. Uniform pricing.

The retailers' profits in the reduced-form game are strictly concave iff, for $i = A, B$,

$$\frac{\partial^2 \pi_i^{UP}}{\partial m_i^2} < 0 \Leftrightarrow \frac{3(\beta^2 - \gamma^2)(5 - 24\beta) + 49\beta^2}{72\beta(\beta^2 - \gamma^2)} < 0.$$

This leads to Condition 1 as $\beta > \gamma > 0$.

There is a unique investment equilibrium if, for $i,j = A, B$ and $i \neq j$,

$$\frac{\partial^2 \pi_i^{UP}}{\partial m_i^2} + \frac{\partial^2 \pi_i^{UP}}{\partial m_i \partial m_j} < 0 \Leftrightarrow \frac{9(\beta^2 - \gamma^2)(1 - 4\beta) + 7\beta^2}{36\beta(\beta^2 - \gamma^2)} \equiv \Phi_3 < 0.$$

Note that Condition 1 is a sufficient condition for $\Phi_3 < 0$ and also for $\Phi_1 < 0$.

Proof of Proposition 1

(a) Using (6) and (8), $m^{PD} - m^{UP} = - q_A^U \gamma/(2\beta\Phi_2) > 0$ where $q_A^U > 0$ is the equilibrium quantity of U supplied by retailer A under uniform pricing. The inequality follows from $\Phi_2 < 0$, which holds if Condition 1 does.

(b) Using (7) and (9), $w^{PD} - w^{UP} = - (m^{PD} - m^{UP})\gamma/(2\beta) < 0$.

(c) The equilibrium total quantities of U under wholesale price discrimination and uniform pricing are, respectively,

$$q_{PD}^U = \frac{\beta[(4 - 9\beta)\alpha + 9\gamma(\alpha - c)]}{3[3(1 - 3\beta)\bar{\beta} + \beta^2]} \quad \text{and} \quad q_{UP}^U = \frac{4\beta[(4 - 9\beta)\alpha + 9\gamma(\alpha - c)]}{3[9(1 - 4\beta)\bar{\beta} + 7\beta^2]}, \tag{A1}$$

where $\bar{\beta} = \beta^2 - \gamma^2$. Then, $q_{PD}^U - q_{UP}^U = - (m^{PD} - m^{UP})\gamma/[3(\beta^2 - \gamma^2)] < 0$.

(d) The equilibrium total quantities of S under wholesale price discrimination and uniform pricing are, respectively,

$$q_{PD}^S = \frac{-[\gamma(2 - 9\beta)\alpha + 9\breve{\beta}(\alpha - c)]}{3[3(1 - 3\beta)\bar{\beta} + \beta^2]} \quad \text{and} \quad q_{UP}^S = \frac{-2[\gamma(1 - 18\beta)\alpha + 18\breve{\beta}(\alpha - c)]}{3[9(1 - 4\beta)\bar{\beta} + 7\beta^2]}, \tag{A2}$$

where $\breve{\beta} = 2\beta^2 - \gamma^2$. Then, $q_{PD}^S - q_{UP}^S = (m^{PD} - m^{UP})(2\beta^2 - \gamma^2)/[3\beta(\beta^2 - \gamma^2)] > 0$.

(e) The equilibrium retail prices of U under wholesale price discrimination and uniform pricing are, respectively,

$$P_{PD}^U = \frac{[(7 - 18\beta)\bar{\beta} + \beta^2]\alpha + 9\gamma \times \bar{\beta}(\alpha - c)}{3[3(1 - 3\beta)\bar{\beta} + \beta^2]} \quad \text{and} \quad P_{UP}^U = \frac{[(25 - 72\beta)\bar{\beta} + 7\beta^2]\alpha + 36\gamma \times \bar{\beta}(\alpha - c)}{3[9(1 - 4\beta)\bar{\beta} + 7\beta^2]}.$$

Then, $P_{PD}^U - P_{UP}^U = - (m^{PD} - m^{UP})\gamma/(3\beta) < 0$. The equilibrium retail prices of S under wholesale price discrimination and uniform pricing are, respectively,

$$P_{PD}^S = \frac{3[3(1 - \beta)\bar{\beta} + \beta^2]\alpha - 2\gamma\beta\alpha - 18\beta\bar{\beta}c}{3[3(1 - 3\beta)\bar{\beta} + \beta^2]} \quad \text{and} \quad P_{UP}^S = \frac{3[3(3 - 4\beta)\bar{\beta} + 7\beta^2]\alpha - 14\gamma\beta\alpha - 72\beta\bar{\beta}c}{3[9(1 - 4\beta)\bar{\beta} + 7\beta^2]}.$$

Then, $P_{PD}^S - P_{UP}^S = - 2(m^{PD} - m^{UP})/3 < 0$ for product S. □

Proof of Proposition 2 Consumers' gross utility from consumption is

$$V = \alpha q^U + \alpha q^S - 1/2[\beta(q^U)^2 + 2\gamma q^U q^S + \beta(q^S)^2].$$

Total welfare is consumers' gross utility minus total costs. Using (6)–(9), (A1), and (A2), the total welfare, upstream profit, and downstream welfare differences between wholesale price discrimination and uniform pricing are

$$\begin{aligned} W^{PD} - W^{UP} &= (m^{PD} - m^{UP})^2[3\Phi_3 - \gamma^2/12\beta(\beta^2 - \gamma^2)] < 0, \\ \pi_M^{PD} - \pi_M^{UP} &= [(w^{PD})^2 - (w^{UP})^2][2\beta/3(\beta^2 - \gamma^2)] < 0, \\ (W^{PD} - \pi_M^{PD}) - (W^{UP} - \pi_M^{UP}) &= (m^{PD} - m^{UP})^2[-\Phi_3 + \gamma^2/12\beta(\beta^2 - \gamma^2)] > 0, \end{aligned}$$

where the inequalities follow from $\Phi_3 < 0$, which holds if Condition 1 does. □