Price Discrimination in Input Markets: Downstream Entry and Welfare*

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The extant theory on price discrimination in input markets takes the structure of the intermediate industry as exogenously given. This paper endogenizes the structure of the intermediate industry and examines the effects of permitting third-degree price discrimination on market structure and welfare. We identify situations where permitting price discrimination leads to either higher or lower wholesale prices for all downstream firms. These findings are driven by the fact that upstream profits are discontinuous due to entry being costly. Moreover, permitting price discrimination fosters entry which in many cases improves welfare. Nevertheless, entry can also reduce welfare because it may lead to a severe inefficiency in production.

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1 INTRODUCTION

"There are several ways in which the manufacturer may influence the number of retailers. [...] [T]he manufacturer may indirectly control the number of dealers through his pricing policy [...]."

— Michael L. Katz (1989)

An ubiquitous assumption in the extant theory on third-degree price discrimination in input markets—different wholesale contracts for different retailers—is that the structure of the intermediate industry is rigid. Abstracting from entry into the intermediate industry ignores the fact that pricing decisions of the upstream manufacturer are a major determinant of the resulting industry structure and market outcome. These pricing decisions in turn are determined by the pricing instruments available to the manufacturer, in particular whether price discrimination is feasible or not. In this paper, we endogenize the structure of the intermediate industry and examine the effects of permitting third-degree price discrimination in input markets on industry structure and welfare.

That the pricing instruments available to an upstream monopolist have an impact on the structure of the downstream industry—i.e., the number of active firms and markets that are served—was argued, for instance, in the case AKZO N.V. v. USITC (800 Fed 2d 1471, Fed. Circ. 1986). Du Pont, a monopolistic provider for the patented aramid fiber Kevlar®, charged

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different wholesale prices for different end uses of Kevlar® in unrelated downstream markets. In particular, the Kevlar® price charged in markets for friction products and gaskets, markets previously served predominantly by asbestos, has been significantly lower than the average price for Kevlar®.[1] AKZO filed a lawsuit at the ITC, arguing that the third-degree price discrimination practice of Du Pont constituted an abuse of its dominant position. The economic experts providing testimony on Du Pont's behalf successfully argued that the imposition of a uniform price would have substantially increased the price for Kevlar® in the friction/sealer market and in consequence would have resulted in the loss of that use for the aramid fiber Kevlar®. The AZKO case thus vividly illustrates that an upstream manufacturer's ability to engage in price discrimination can lead to a very different downstream market structure, and in particular to more markets being served by that manufacturer, than uniform pricing.

Another illustration of the potential impact of price discrimination on downstream market structure is found on the other side of the Atlantic ocean. In a case of geographic price discrimination, the United Brands Company (UBC) charged Olesen, one of its largest Danish retailers for Chiquita bananas, a price which was 138% higher than the price charged from Irish retailers.[2] Moreover, UBC started subsequently to reduce the orders placed by Olesen, a behavior culminating in UBC terminating to supply Olesen with Chiquita bananas. This conduct severely damaged Olesen's business interest and eventually might have caused Olesen to exit the market for bananas, if UCB—in response to a complaint filed by Olesen to the European Commission—had not resumed its supply of Chiquita bananas. UBC's justification of its discriminatory pricing practice alluded to the attempt to charge each geographic market the price it could bear.[3] This suggests that dominant manufacturers charge wholesale prices such that the participation constraints of retailers in independent markets—even for those retailers operating in the most profitable markets—are binding. We investigate in detail the welfare effects of a ban on price discrimination when the entry or exit constraint of one or more retailers imposes a binding restriction on the manufacturer's choice of wholesale prices.

We conduct our analysis in the standard framework of vertical relations between an upstream manufacturer and downstream retailers. Our modeling assumptions are shared by a large part of the extant literature: a monopolistic manufacturer supplies an input that is used by an intermediate industry to produce a final product. The manufacturer makes a take-it-or-leave-it offer to each of two downstream firms, an incumbent and a potential entrant, specifying a per-unit wholesale price at which that firm can procure any desired quantity of the input. The new feature in our model is that one of the downstream firms—the entrant—has to decide, after observing the offered wholesale prices, whether to incur a strictly positive fixed cost in order to become active in the intermediate industry.

In our benchmark model we assume that downstream firms operate in separate markets. We show that for relatively high values of the entry cost, entry occurs under price discrimination but not under uniform pricing. With entry—i.e., market opening—being unambiguously welfare improving, in this case, price discrimination is socially desirable because entry is promoted. The more interesting cases arise for intermediate values of the entry cost, where, under both pricing regimes, the entry constraint imposes a binding restriction on the manufacturer's optimal choice of wholesale prices but entry nevertheless occurs. Depending on the relative efficiency of the potential entrant, in these cases price discrimination can lead to overall lower as well as overall higher wholesale prices compared to uniform pricing, which

[1] See Section 4 in Hausman and MacKie-Mason (1988) for a more detailed description of this case.

[2] See Chiquita case, Commission decision 76/353/EEC(1976) OJ L 95/1.

[3] This argument was rejected by the Commission. For a more elaborate description of this case see Russo et al. (2010).

immediately translates into price discrimination being strictly welfare enhancing or welfare reducing, respectively.

What is the intuition underlying these latter results? In the absence of the entry cost, under price discrimination it would be the more efficient downstream firm that is discriminated against because the manufacturer charges a higher wholesale price to the downstream firm with the less elastic demand. The uniform wholesale price charged by the manufacturer in the absence of the entry cost is bracketed by these discriminatory wholesale prices. First, imagine that the entrant is less efficient and thus, if there was no entry cost, receives a discount under price discrimination. With the entry constraint imposing a binding restriction under either pricing regime, the manufacturer has to offer the entrant an even lower wholesale price that allows the entrant just to break even. This restricted wholesale price, which is the same under both pricing regimes, is passed on to the incumbent only under uniform pricing but not under price discrimination, where the incumbent is charged a relatively high wholesale price. In this scenario uniform pricing leads to lower wholesale prices for all downstream firms. Next, imagine that the entrant is more efficient and thus, in the absence of the entry cost, would be charged a higher wholesale price than the incumbent. For low-intermediate values of the entry cost the entry constraint imposes a "hardly" binding restriction under uniform pricing, but is quite distinctly binding under price discrimination. Thus, the restricted wholesale price that allows the entrant to break even is slightly lower than the unrestricted uniform price but higher than the relatively low discriminatory wholesale price for the less efficient incumbent. In this case, uniform pricing leads to weakly higher prices for all downstream firms. For high-intermediate values of the entry cost, the restricted wholesale price is below the incumbent's discriminatory wholesale price. With the restricted wholesale price being charged also from the incumbent only under uniform pricing, uniform pricing here leads to weakly lower wholesale prices for all downstream firms. These results prove to be robust with regard to the number of downstream firms, downstream exit (instead of entry), and nonlinear wholesale contracts.

We also consider downstream Cournot competition. Here, if entry occurs, the entrant and the incumbent are active in the same market. While with separate downstream markets entry under price discrimination but not under uniform pricing is a sufficient condition for permitting price discrimination to be welfare enhancing, this does not hold true for competition. If downstream firms compete à la Cournot, then entry alleviates the quantity distortion arising from double marginalization. Under price discrimination, however, this beneficial effect of entry is counteracted by an allocative inefficiency in production induced by the upstream supplier's discrimination against the more efficient firm. For a very inefficient entrant and/or very high cost of entry, this negative effect can outweigh the benefits of entry, which in consequence makes uniform pricing socially desirable—even though it leads to less firms being served than price discrimination.

The rest of the paper is organized as follows: Section 2 reviews the related literature. We introduce our model with downstream firms operating in separate markets in Section 3 and analyze it in Section 4. In Sections 5 and 6, we address robustness of our results with respect to the presence of multiple downstream firms on the one hand, and downstream exit on the other hand. After allowing for nonlinear wholesale contracts in Section 7, we introduce downstream Cournot competition in Section 8. We conclude in Section 9.

2 Related Literature

The theoretical debate about the welfare effects of permitting third-degree price discrimination in intermediate-goods markets was initiated by Katz (1987), who shows that price discrimination reduces welfare unless it prevents inefficient backward integration into the production process.[4] This finding is generalized by DeGraba (1990) to a long-run analysis where downstream firms can invest in cost reduction. Price discrimination decreases welfare also in the long run due to a reduction of investment incentives.[5]

More recent contributions relax the assumption that the manufacturer has all the bargaining power. Inderst and Valletti (2009) posit that downstream firms have access to an alternative source of input supply and show that this results in the more efficient firm receiving a discount. In consequence, price discrimination provides higher incentives to invest in cost reduction and thus—at least for linear demand—can result in higher welfare than uniform pricing. O'Brien (forthcoming) assumes that wholesale prices are determined by Nash bargaining. This also gives rise to circumstances where price discrimination is socially desirable.

Last, O'Brien and Shaffer (1994) and Inderst and Shaffer (2009) relax the assumption that the manufacturer is restricted to linear wholesale prices and allow for two-part tariffs. In O'Brien and Shaffer (1994), while uniform pricing may benefit downstream firms, it always does so at the expense of consumers and welfare.[6] In the setting of Inderst and Shaffer (2009) uniform pricing reduces allocative efficiency and can lead to higher wholesale prices for all downstream firms, resulting in lower welfare.

All the aforementioned papers take the structure of the intermediate industry as exogenously given. This paper, in contrast, endogenizes the structure of the intermediate industry by allowing for costly entry, and derives implications of permitting price discrimination for industry structure and welfare. As was first reasoned by Bork (1978), allowing a final-good monopolist to price discriminate can lead to more markets being served, which in turn improves welfare. This entry-promoting and in turn welfare-improving effect of price discrimination is also operative in our model. But even when all markets are served under both pricing regimes, we identify circumstances where price discrimination leads to either overall higher or overall lower prices than uniform pricing. These cases arise from entry being costly and do not crucially rely on any assumptions on the demand function. Thus, in a nutshell, the welfare implications of banning third-degree price discrimination with an endogenous market structure for final-good markets do not extend to the case of intermediate-good markets. To the best of our knowledge, the only paper that also considers endogeneity of the market structure in intermediate good markets is Haucap and Wey (2011). Abstracting from any real entry decision in the sense of incurring an entry cost, their findings, in contrast to our results, closely parallel the findings for final-good markets.[7]

3 A MODEL OF SEPARATE MARKETS

Consider a vertically related industry where the upstream market is monopolized by manufacturer M. This manufacturer produces an essential input that is supplied to a downstream sector. For simplicity we assume that M produces without costs. There are potentially two downstream firms, $i \in \{I, E\}$, that transform one unit of input into one unit of a final good. While firm I, the incumbent, is already active, firm E, the entrant, has to expend an entry cost $F > 0$ to become active in the downstream industry. Downstream firm i produces at

[4] Yoshida (2000) extends this model to the case where downstream firms operate with Leontief-type technologies. Valletti (2003) generalizes the results obtained in Yoshida (2000) beyond the case of linear demand.

[5] Arya and Mittendorf (2010) show that price discrimination can be welfare enhancing if downstream firms operate not only in one but in multiple markets.

[6] Analyzing a similar model but assuming that the manufacturer competes against a fringe, Caprice (2006) shows that uniform pricing may cause welfare to increase.

[7] See Schmalensee (1981) and Hausman and MacKie-Mason (1988).

constant marginal cost $k_i \in \{0, k\}$, $k > 0$, and without fixed cost. Downstream firms differ in their marginal cost of production, $k_I \neq k_E$, i.e., either the incumbent or the entrant has a cost advantage of $k > 0$.

The sequence of events is as follows: first, M makes a take-it-or-leave-it offer to each downstream firm.[8] Under price discrimination, M offers each downstream firm a possibly different wholesale price w_i, whereas under uniform pricing the same price $w_i = w$ applies to both firms.[9] Thus, upon accepting M's offer, downstream firm i's effective marginal cost is $c_i = w_i + k_i$.[10] In stage two, after observing the contracts offered by M, E decides whether to enter the downstream industry at cost F. In stage three, all active firms in the downstream industry purchase a nonnegative quantity of the input from M, transform this input into the final good, and sell the produced output to consumers.

First, we focus on the case where the downstream firms serve independent markets. Both markets are symmetric and characterized by the same inverse demand function $P(q)$, which is strictly decreasing and thrice differentiable where $P > 0$. Moreover, we impose the standard assumption $P'(q) < \min\{0, -qP''(q)\}$ where $P > 0$.[11] The equilibrium concept employed is subgame perfect Nash equilibrium in pure strategies.

We impose an additional assumption that ensures that M's maximization problem is well-behaved under either pricing regime.

Assumption (A1): *Downstream marginal revenue is concave, $3P''(q) + qP'''(q) \leq 0$, whenever $P > 0$.*

Next to technical issues, there is another reason for this assumption: as was shown by Katz (1987), if downstream firms engage in Cournot competition, then under price discrimination the downstream firm with the lower marginal cost will be charged a higher wholesale price than the downstream firm with the higher marginal cost.[12] The firm with lower own marginal cost has the more inelastic demand for the input, which causes the manufacturer to charge this firm a higher price. While the peculiarity of Cournot competition that total output only depends on the sum of effective marginal costs allows Katz (1987) to obtain this result in considerable generality, this is not possible in the case of separate markets. Here, Assumption (A1) provides a sufficient condition for the demand of the more efficient downstream firm being less elastic, which in turn implies that price discrimination results in a higher wholesale price for the more efficient firm. Thus, next to reasons of analytical convenience, we impose this assumption in order to maintain comparability to earlier contributions to the literature on price discrimination in input markets.

We restrict attention to situations where M considers it optimal to serve both firms under uniform pricing at least for sufficiently small entry cost. A sufficient condition for this is that the less efficient firm is not too inefficient in the sense that it demands a strictly positive quantity when charged the optimal (unrestricted) discriminatory wholesale price $w^d(0)$ for

[8] As argued by Inderst and Shaffer (2009, p.660), the assumption of the manufacturer having all the bargaining power "can be justified on the grounds that for antitrust purposes the considerations of price discrimination in intermediate-goods markets is primarily relevant if the supplier enjoys a dominant position."

[9] As argued in Inderst and Valetti (2009, 2011), the assumption of linear wholesale prices can be defended on grounds of possible realism. Iyer and Villas-Boas (2003) and Milliou et al. (2009) provide theoretical support for the use of linear wholesale contracts.

[10] We abstract from any commitment problems and assume that M can credibly commit to the prices quoted in this first stage. At a later point we make clear, which of our results are driven by this assumption.

[11] See, for example, Vives (1999).

[12] This result holds as long as there are no additional restrictions on the manufacturer's price setting, such as backward integration by downstream firms (Katz, 1987) or demand-side substitution (Inderst and Valletti, 2009).

the more efficient firm.[13] Formally, letting the optimal quantity produced by an active downstream firm i be denoted by $q(c_i) := \arg\max_q \{q[P(q) - c_i]\}$, we impose the following assumption:

Assumption (A2): *Marginal cost k is such that $q(w^d(0) + k) > 0$.*

As a tie-breaking rule, we assume that M serves only the incumbent market when indifferent between the two possible structures the intermediate industry can take. Lastly, superscripts d and u refer to the discriminatory and the uniform pricing regime, respectively.

4 THE ANALYSIS

As a preliminary consideration, note that an active downstream firm in stage 3 realizes gross profits $\pi(c_i) := q(c_i)[P(q(c_i)) - c_i]$, and that both $q(c_i)$ and $\pi(c_i)$ are strictly decreasing in the effective marginal cost c_i where $q > 0$. Imagine that there is no entry cost such that both downstream firms are active in the downstream industry. The optimal discriminatory wholesale price for M to charge from firm $i \in \{I, E\}$ is

$$w^d(k_i) := \arg\max_w \{wq(w + k_i)\}. \quad (1)$$

Under uniform pricing, on the other hand, M chooses the common wholesale price

$$w^u(k) := \arg\max_w \{wq(w + k) + wq(w)\}. \quad (2)$$

We will refer to $w^d(k_i)$ and $w^u(k)$ as unrestricted wholesale prices because they represent the optimal prices for M to offer as long as the entry cost does not impose a binding restriction under the respective pricing regime. We now can establish that the unrestricted uniform wholesale price is bracketed by the two unrestricted discriminatory wholesale prices. More precisely, under price discrimination the less efficient firm receives a discount compared to uniform pricing. This discount, however, does not outweigh its cost disadvantage.

Lemma 1: *Given $(A1)$ and $(A2)$, then $w^d(k) < w^u(k) < w^d(0) < w^d(k) + k$.*[14]

Beside these unrestricted wholesale prices, the wholesale price which allows the potential entrant just to recoup its fixed entry cost will play a prominent role in the upcoming analysis. Given F and $k_E \in \{0, k\}$, let $w^R(F; k_E)$ denote the wholesale price which equates the entrant's gross profit with the cost of entry,

$$\pi(w^R(F; k_E) + k_E) \equiv F. \quad (3)$$

Note that $w^R(F; k_E)$, which strictly decreases in F, is the highest price at which M can induce E to enter. Thus, if M wishes to achieve downstream entry but cannot do so by charging the unrestricted wholesale price because the entry cost is too high, the best M can do is to charge the entrant price $w^R(F; k_E)$. Therefore, we refer to $w^R(F; k_E)$ as the restricted wholesale price.

Next, we derive several thresholds of the entry cost that are crucial to determine the optimal wholesale prices and the resulting structure of the downstream industry. Under either pricing regime, if the entry cost exceeds a certain threshold, the entry constraint imposes a binding

[13] We call the wholesale price restricted (unrestricted) if the entry constraint imposes (does not impose) a binding restriction on the manufacturer in his optimal choice of wholesale prices.

[14] Note that the unrestricted uniform wholesale price $w^u(k)$ does not depend on whether the incumbent or the entrant is the more efficient downstream firm.

restriction on M in his choice of wholesale prices. While it is still optimal to serve both downstream firms if the entry constraint is just binding, this does not hold true if the entry cost is relatively high. Then, M optimally serves only the incumbent.

The first set of thresholds, $\bar{F}^d(k_E)$ and $\bar{F}^u(k_E)$, characterizes when the entry cost indeed imposes a binding restriction. Entry occurs at the unrestricted wholesale price as long as the entry cost is below

$$\bar{F}^d(k_E) := \pi(w^d(k_E) + k_E) \tag{4}$$

under price discrimination and below

$$\bar{F}^u(k_E) := \pi(w^u(k) + k_E) \tag{5}$$

under uniform pricing.

At the second type of thresholds, $\hat{F}^d(k_E)$ and $\hat{F}^u(k_E)$, M is indifferent between inducing entry and serving the incumbent firm alone. With regard to price discrimination, M will not consider it profitable to make E enter the downstream industry if the entry cost exceeds

$$\hat{F}^d(k_E) := \pi(k_E). \tag{6}$$

For $F \geq \hat{F}^d(k_E)$ there are no gains from trade to be realized, and therefore we restrict attention to $F < \hat{F}^d(k_E)$. Under uniform pricing, on the other hand, once M has to lower the wholesale price below $w^u(k)$ in order to make E willing to enter, M has to pass-through this discount price $w^R(F; k_E)$ also to I. While it remains optimal for M to serve both downstream firms as long as the entry cost only slightly exceeds $\bar{F}^u(k_E)$, this is not the case anymore if entry is very costly because $w^R(F; k_E)$ is strictly decreasing in F. Formally, if the entry cost exceeds $\hat{F}^u(k_E)$, implicitly defined by

$$\begin{aligned} w^R(\hat{F}^u(k_E); k_E)[q(w^R(\hat{F}^u(k_E); k_E) + k_E) + q(w^R(\hat{F}^u(k_E); k_E) + k_I)] \\ = w^d(k_I)q(w^d(k_I) + k_I), \end{aligned} \tag{7}$$

M prefers to serve only I at the high wholesale price $w^d(k_I)$ instead of serving both downstream firms at the low wholesale price $w^R(F; k_E)$.[15]

Regarding an ordering of the above thresholds, we can make the following observations. The ordering of the unrestricted wholesale prices in Lemma 1 immediately implies that $\bar{F}^u(k) < \bar{F}^d(k)$ and $\bar{F}^d(0) < \bar{F}^u(0)$ because M considers it optimal to discriminate against a more efficient downstream firm if unrestricted in its wholesale pricing. Next, since $w^R(\bar{F}^u(k_E); k_E) \equiv w^u(k)$ and $w^R(\hat{F}^d(k_E); k_E) \equiv 0$, continuity of upstream profits implies $\bar{F}^u(k_E) < \hat{F}^u(k_E) < \hat{F}^d(k_E)$. Intuitively, while it remains optimal for M to serve both downstream firms under uniform pricing if the entry cost only slightly exceeds $\bar{F}^u(k_E)$, it does not pay off for M to induce entry if the restricted common wholesale price necessary to do so is close to zero. Therefore, way before charging a zero wholesale price to both firms, M prefers not to serve E at all. Moreover, $\bar{F}^d(k_E) < \hat{F}^d(k_E)$ because M would always serve E if the entry cost does not impose a binding restriction. Last, whether $\bar{F}^d(k)$ is greater or smaller than $\hat{F}^u(k)$ remains undetermined in general. This discussion is summarized in the following observation (See also Figures 1–3).

Observation 1: *Given* $(A1)$ *and* $(A2)$*, if the potential entrant is*

[15] Strictly speaking, $\hat{F}^u$ depends on both k_E and k_I. Since we assume asymmetry of downstream firms, $k_E \neq k_I$, there is, however, no loss in regarding $\hat{F}^u$ as a function of k_E alone.

(i) less efficient, $k_E = k$ *and* $k_I = 0$*, then*

$$\bar{F}^u(k) < \min\{\bar{F}^d(k), \hat{F}^u(k)\} \leq \max\{\bar{F}^d(k), \hat{F}^u(k)\} < \hat{F}^d(k);$$

(ii) more efficient, $k_E = 0$ *and* $k_I = k$*, then*

$$\bar{F}^d(0) < \bar{F}^u(0) < \hat{F}^u(0) < \hat{F}^d(0).$$

4.1 Optimal Wholesale Pricing

Under price discrimination, I will always be charged its respective unrestricted discriminatory wholesale price, $w^d(k_I)$. With regard to E, as long as $F \leq \bar{F}^d(k_E)$, M charges the optimal unrestricted wholesale price $w^d(k_E)$ because E is willing to enter at this price. If the entry cost lies in the range $(\bar{F}^d(k_E), \hat{F}^d(k_E))$, M considers it optimal to induce entry by charging E the restricted wholesale price $w^R(F; k_E)$ because there are still gains from trade to be realized.

A qualitatively similar picture prevails under uniform pricing. For $F \leq \bar{F}^u(k_E)$ the entry cost does not impose a binding restriction and M charges the unrestricted wholesale price $w^u(k)$. As long as the entry cost is not overly high, $F \in (\bar{F}^u(k_E), \hat{F}^u(k_E))$, M is willing to cut back on the common wholesale price and to charge $w^R(F; k_E)$ in order to induce entry and to serve both downstream firms. For $F \geq \hat{F}^u(k_E)$, however, the concession in the common wholesale price necessary to induce entry becomes too costly. In this case, M prefers E to stay out of the downstream industry and to serve I alone at its unrestricted discriminatory wholesale price $w^d(k_I)$.

Letting wholesale prices in equilibrium be denoted by $\{w_E^d, w_I^d\}$ and w^u under price discrimination and uniform pricing, respectively, allows us to summarize the above discussion as follows:

Observation 2: *In equilibrium, the optimal wholesale price(s)*

(i) under price discrimination are $w_E^d = w^d(k_E)$ *for* $0 < F \leq \bar{F}^d(k_E)$, $w_E^d = w^R(F; k_E)$ *for* $\bar{F}^d(k_E) < F < \hat{F}^d(k_E)$*, and* $w_I^d = w^d(k_I)$.[16]

(ii) under uniform pricing is $w^u = w^u(k)$ *for* $0 < F \leq \bar{F}^u(k_E)$, $w^u = w^R(F; k_E)$ *for* $\bar{F}^u(k_E) < F < \hat{F}(k_E)$*, and* $w^u = w^d(k_I)$ *for* $\hat{F}^u(k_E) \leq F$.

The optimal wholesale prices as a function of the entry cost are depicted in Figures 1 and 2 for a less efficient entrant and in Figure 3 for a more efficient entrant.

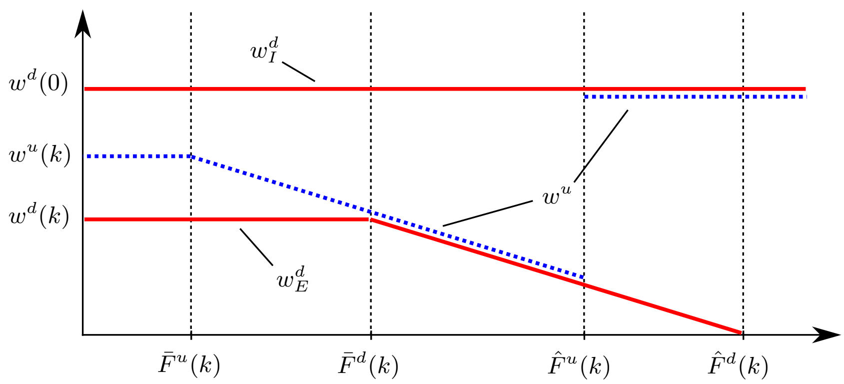

Figure 1: Optimal wholesale prices with $k_E = k$ and $\bar{F}^d(k) < \hat{F}^u(k)$.

[16]Note that for $F \geq \hat{F}^d(k_E)$ the discriminatory wholesale price charged to firm E is not uniquely defined because any positive wholesale price is compatible with entry not taking place.

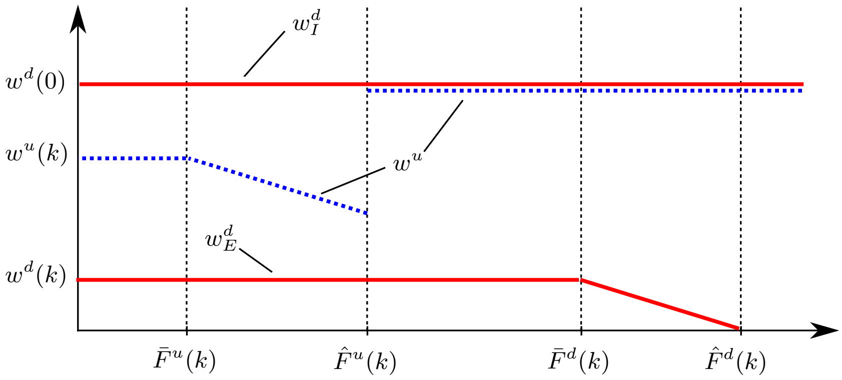

Figure 2: Optimal wholesale prices with $k_E = k$ and $\hat{F}^u(k) < \bar{F}^d(k)$.

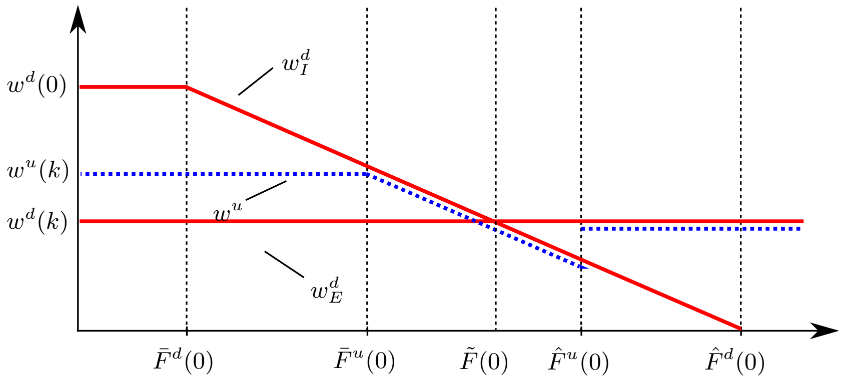

Figure 3: Optimal wholesale prices with $k_E = 0$.

4.2 Welfare Implications of Banning Price Discrimination

Welfare is defined as the unweighted sum of consumer and producer surplus. We express changes in economic variables due to a regime shift from uniform pricing to price discrimination using symbol Δ. If both firms are active in the downstream industry, then the change in welfare due to a regime shift amounts to

$$\Delta W \equiv \sum_{i \in \{I,E\}} \left\{ \int_{q(w^u+k_i)}^{q(w_i^d+k_i)} P(x)dx - k_i \left[q(w_i^d + k_i) - q(w^u + k_i) \right] \right\}. \tag{8}$$

Ceteris paribus entry into the downstream industry is always beneficial from a welfare point of view, since E enters only if it generates a surplus that exceeds the entry cost. Letting Q denote the total quantity sold, we obtain the following welfare implications for the case of a less efficient entrant.

Proposition 1: *Suppose $k_E = k$ and $k_I = 0$. Given $(A1)$ and $(A2)$, if*
(i) $F < \min\{\hat{F}^u(k), \bar{F}^d(k)\}$, then $\Delta Q \le 0$ implies $\Delta W < 0$;
(ii) $\bar{F}^d(k) \le F < \hat{F}^u(k)$, then $\Delta W < 0$;
(iii) $\hat{F}^u(k) \le F < \hat{F}^d(k)$, then $\Delta W > 0$.

Cases (i) and (iii) of Proposition 1 are well understood by now: for low values of the entry cost, case (i), entry occurs under both pricing regimes and price discrimination leading to a reduction of total output is a sufficient condition for price discrimination to be welfare harming.[17] For high values of the entry cost, case (iii), price discrimination fosters entry which in turn improves welfare because the market outcome in the incumbent market is independent of the pricing regime.[18]

Case (ii), on the other hand, embodies a novelty. For intermediate values of the entry cost both downstream firms are served under either pricing regime. With the manufacturer being restricted in his price setting under both pricing regimes, the entrant receives wholesale price w^R irrespectively of the regime. This low wholesale price is passed on to the incumbent firm only under uniform pricing but not under price discrimination. Hence, uniform pricing leads to (weakly) lower wholesale prices for all downstream firms. In consequence, welfare in the entrant's market is the same under both pricing regimes, whereas welfare in the incumbent's market is strictly higher under uniform pricing than under price discrimination. Thus, even though market-opening occurs under both pricing regimes, price discrimination is unambiguously found to be detrimental for welfare.[19]

In order to state the welfare implications of banning price discrimination for the case of a more efficient entrant, we have to introduce one additional threshold with regard to the entry cost. Remember that $w^R(\bar{F}^u(0);0) \equiv w^u(k)$ and that the restricted wholesale price continuously decreases all the way down to zero as the entry cost increases. In consequence, there exists a value $\tilde{F}(0)$ of the entry cost, implicitly defined by

$$w^R(\tilde{F}(0),0) \equiv w^d(k), \tag{9}$$

where the restricted wholesale price with respect to the more efficient entrant equals the unrestricted discriminatory wholesale price charged from the less efficient incumbent (see Figure 3). Under uniform pricing, M can serve both downstream firms by charging the wholesale price $w^R(\tilde{F}(0),0) = w^d(k)$. Thus, for F slightly higher than $\tilde{F}(0)$, M prefers to serve both firms at price $w^R(F,0)$ instead of serving only the incumbent at price $w^d(k)$. This implies $\tilde{F}(0) \in (\bar{F}^u(0), \hat{F}^u(0))$.

Proposition 2: *Suppose $k_E = 0$ and $k_I = k$. Given $(A1)$ and $(A2)$, if*

(i) $F < \bar{F}^u(0)$, *then* $\Delta Q \leq 0$ *implies* $\Delta W < 0$,
(ii) $\bar{F}^u(0) \leq F < \tilde{F}(0)$, *then* $\Delta W > 0$,
(iii) $\tilde{F}(0) < F < \hat{F}^u(0)$, *then* $\Delta W < 0$,
(iv) $\hat{F}^u(0) \leq F < \hat{F}^d(0)$, *then* $\Delta W > 0$.

Cases (i), (iii), and (iv) are basically known from the previous analysis of a less efficient entrant, which is why we focus on the interesting novelty found in case (ii). Here, for low-intermediate values of the entry cost, under both pricing regimes the manufacturer is restricted in its price setting but nevertheless induces entry. Importantly, while the manufacturer is hardly restricted in his price setting under uniform pricing, under price discrimination the reduction in E's wholesale price is substantial, i.e., $w^d(k_I) < w^R(\cdot,0) < w^u(k)$. Thus, price discrimination leads to (weakly) lower wholesale prices for both downstream firms. In consequence, price discrimination strictly increases welfare, even though it does not lead to more markets being served than uniform pricing. This effect does neither occur with a less efficient entrant nor if the manufacturer sells directly to final consumers.

[17] This finding clearly parallels Schmalensee's (1981) result on third-degree price discrimination in final-good markets. A series of papers elaborates on Schmalensee's basic insight, see Varian (1985), Schwartz (1990), Malueg (1993), and Aguirre et al. (2010). For overviews on price discrimination in final-good markets, see Armstrong

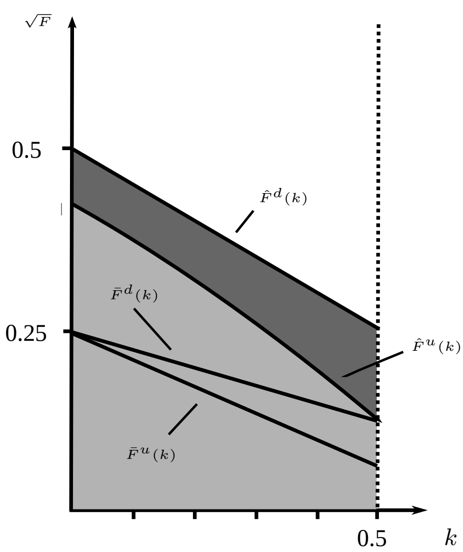

Figure 4: Linear demand and $k_E = k$.

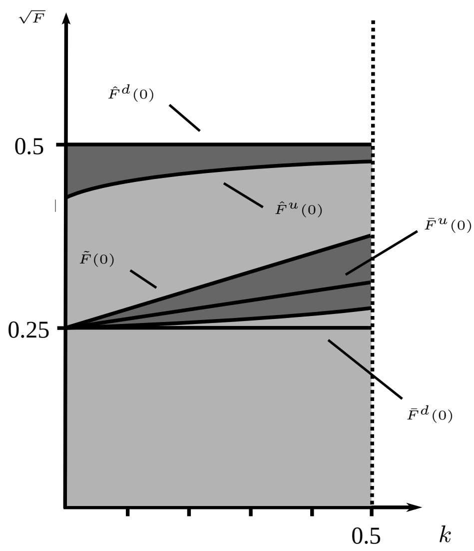

Figure 5: Linear demand and $k_E = 0$.

Figures 4 and 5 illustrate the above discussion for the case of a linear inverse demand function, $P(q) = \max\{1 - q, 0\}$.[20] Price discrimination improves welfare in the dark-gray shaded areas and reduces welfare in the light-gray shaded areas. This application with linear demand shows that the novel pricing results identified above occur for a relatively wide range of parameter values. (Note that in Figures 4 and 5 we rephrased the thresholds regarding the entry cost in terms of $\sqrt{F}$, which allows us to represent most thresholds as straight lines; taking this scaling effect into account allows to reconcile the following statements with the areas depicted in Figures 4 and 5.) For example, in the case of a more efficient entrant (Figure 5), for $k_I = 0.25$, in slightly more than 50% of all cases where there is scope for entry to occur ($F < \hat{F}^d(0) = 0.25$), one pricing regime leads to overall lower prices than the other pricing regime ($[\hat{F}^u(0) - \bar{F}^u(0)]/\hat{F}^d(0) \approx 0.5126$). Within these cases, however, uniform pricing is approximately six times likelier than price discrimination to lead to overall lower prices ($\tilde{F}(0) - \bar{F}^u(0) \approx 0.0186$ and $\hat{F}^u(0) - \tilde{F}(0) \approx 0.1096$). Likewise for the case of a less efficient entrant, for $k_E = 0.25$, in roughly 33% of all cases where there is scope for entry to occur ($F < \hat{F}^d(0.25) \approx 0.1206$), uniform pricing leads to overall lower wholesale prices than price discrimination ($[\hat{F}^u(0.25) - \bar{F}^d(0.25)]/\hat{F}^d(0.25) \approx 0.3280$).

(2007) and Stole (2007).

[18]This obviously is the intermediate-market analogue to the classic Chicago-school argument brought forth by Bork (1978), which was formalized by Hausman and MacKie-Mason (1988) as well as Layson (1994).

[19]Note that case (ii) exists only if $\bar{F}^d(k) < \hat{F}^u(k)$. The effect arising in case (ii) depends on the manufacturer's ability to commit to his offers. If commitment is not possible and the entry decision is made before wholesale prices are set, then for $F > \bar{F}^d(k)$ entry occurs under neither pricing regime.

[20]For a linear inverse demand function, Assumption (A2) translates into $k < 1/2$.

5 MULTIPLE FIRMS

Let n_I denote the number of identical downstream incumbents, each of which produces at constant marginal cost k_I, and n_E the number of potential entrants, each of which produces at constant marginal cost k_E. The ratio of potential entrants to incumbents is denoted by $N := n_E/n_I$.[21]

The unrestricted discriminatory wholesale prices $w^d(k_i)$ as well as the restricted wholesale price $w^R(F;k_E)$ do not depend on the number of downstream firms of the respective type. In consequence, $\bar{F}^d(k_E)$ and $\hat{F}^d(k_E)$ remain unchanged.

The unrestricted uniform wholesale price, on the other hand, depends on the ratio of the two types of downstream firms: while still being bracketed by the unrestricted discriminatory prices, the unrestricted uniform wholesale price tends toward $w^d(k_E)$ as entering firms become relatively more numerous. Thus, with unrestricted discriminatory wholesale prices being set in favor of the less efficient firm (cf. Lemma 1), the unrestricted uniform wholesale price increases as N increases for more efficient entrants ($k_E = 0$), and decreases as N increases for less efficient entrants ($k_E = k$). An increase in N thus makes it more (less) likely that the entry cost imposes a binding restriction if entrants are more (less) efficient:

$$\frac{\partial \bar{F}^u(0)}{\partial N} < 0 \quad \text{and} \quad \frac{\partial \bar{F}^u(k)}{\partial N} > 0. \tag{10}$$

M's willingness to cut back on the uniform wholesale price in order to induce entry is affected by the relative size of the group of potential entrants also. Intuitively, the more new markets there are to be opened, the more willing is M to settle for the restricted wholesale price at which entry occurs instead of serving only the incumbent firms at their respective unrestricted discriminatory price. Formally,

$$\frac{\partial \hat{F}^u(k_E)}{\partial N} > 0, \quad k_E \in \{0, k\}. \tag{11}$$

From Proposition 1 (ii) and Proposition 2 (ii) and (iii), it then follows that an increase in the relative number of potential entrants leads to larger scope for our novel pricing results to prevail. With regard to less efficient entrants, an increase in N enlarges the interval $[\bar{F}^d(k), \hat{F}^u(k))$ (or makes it more likely that this case exists in the first place); with regard to more efficient entrants, an increase in N enlarges the interval $[\bar{F}^u(0), \hat{F}^u(0))$. In both cases, potential entrants becoming relatively more numerous makes it more likely that one pricing regime results in overall lower wholesale prices than the other pricing regime.[22]

6 DOWNSTREAM EXIT

Next, we draw out the implications of banning price discrimination for market structure and welfare when firms are initially active but have to expend a cost F, which is the same for both downstream firms, in order to stay active.[23] As before, let $w^R(F;k_i)$ denote the restricted wholesale price at which a downstream firm with marginal cost k_i is just willing to stay active. From (3) it follows that the restricted wholesale price for the more efficient downstream firm

[21] As before, $k_I, k_E \in \{0, k\}$ with $k_I \neq k_E$, and all downstream firms operate in independent markets. A formal derivation of the results is deferred to Appendix B.

[22] As noted above, both $w^d(k)$ and $w^R(F;0)$ do not depend on N. Thus, in the case of more efficient entrants, with $\tilde{F}(0)$ (as defined in (9)) not depending on N, an increase in N increases the scope for both price discrimination leading to overall higher or overall lower wholesale prices.

[23] A formal derivation of the results presented in this section is deferred to Appendix C.

exceeds the restricted wholesale price for the less efficient downstream firm by the difference in efficiency:

$$w^R(F;0) = w^R(F;k) + k. \tag{12}$$

Thus, with F always imposing a more pressing restriction with regard to the less efficient downstream firm, one should expect results under downstream exit to resemble those for a less efficient entrant, at least qualitatively.

Price discrimination.—The optimal wholesale prices are readily identified: for $F \le \bar{F}^d(k_i)$, M offers a downstream firm with marginal cost $k_i \in \{0, k\}$ the unrestricted discriminatory wholesale price $w^d(k_i)$; for $F \in (\bar{F}^d(k_i), \hat{F}^d(k_i))$, this firm is charged the restricted wholesale price $w^R(F; k_i)$; for $F \ge \hat{F}^d(k_i)$, exit occurs.

Uniform pricing.—The optimal uniform wholesale price for low and moderate values of F follows from the previous analysis of entry: for $F \le \bar{F}^u(k)$, M charges the unrestricted wholesale price $w^u(k)$; for $F \in (\bar{F}^u(k), \hat{F}^u(k))$, on the other hand, M is willing to settle for the restricted wholesale price of the less efficient firm in order to keep both downstream firms active.

For $F \ge \hat{F}^u(k)$, if the more efficient downstream firm was willing to stay active when charged its unrestricted discriminatory wholesale price, then M would prefer the less efficient firm to be inactive. Under downstream exit, however, it is possible that M also is restricted with regard to the more efficient firm, i.e., for $F \ge \hat{F}^u(k)$ the more efficient firm possibly prefers to exit when offered $w^d(0)$. Whether this is the case boils down to whether $\hat{F}^u(k)$ exceeds $\bar{F}^d(0)$. This happens if downstream firms differ not too much in efficiency. First, for a small value of k, $\bar{F}^d(0)$ only slightly exceeds $\bar{F}^d(k)$. Second, for a small value of k, charging a wholesale price at which the less efficient firm exits leads to M losing almost half its sales; since this can only be profitable if the restricted wholesale price necessary to keep the less efficient firm active is very low, it follows that $\hat{F}^u(k)$ is relatively large. Thus, for relatively small values of k, M will serve both firms at wholesale price $w^R(F;k)$ even for entry costs slightly above $\hat{F}^u(k)$, instead of serving only the more efficient firm at wholesale price $w^R(F;0)$. For relatively large values of k, on the other hand, M optimally serves only the more efficient firm at a wholesale price equal to $\min\{w^d(0), w^R(F;0)\}$.

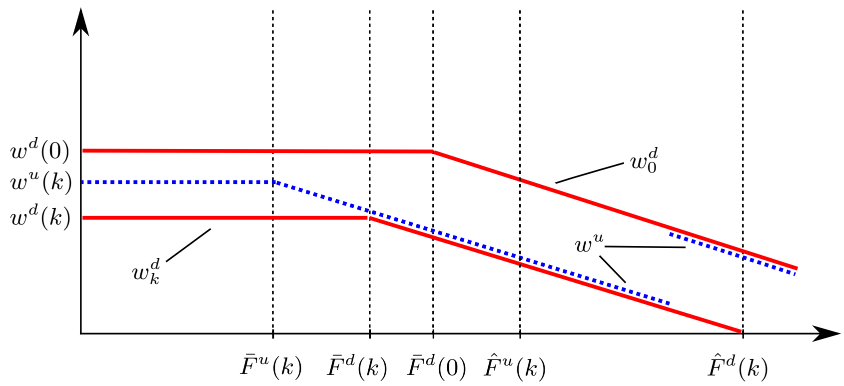

Figure 6: Optimal wholesale prices with k small and $\bar{F}^d(0) < \hat{F}^u(k)$.

Welfare.—As argued in the beginning, the results regarding structure of the downstream industry and welfare resemble those under downstream entry with a less efficient entrant. Instead of reiterating our previous findings, we just want to emphasize M's increased willingness under uniform pricing to keep the less efficient firm in the downstream industry: while entry of a less efficient firm does not occur for an entry cost higher than $\hat{F}^u(k)$, under downstream exit, if k is not too high, the less efficient firm is kept alive even for F exceeding this threshold. Since this pricing behavior results in lower wholesale prices for both downstream firms, there is more scope for uniform pricing to increase welfare under downstream exit than under downstream entry of a less efficient firm. This case is illustrated in Figure 6.

7 NONLINEAR WHOLESALE CONTRACTS

In what follows, we abandon the assumption of linear wholesale prices and consider on two-part tariffs consisting of a fixed fee $T \in \mathbb{R}$ and a unit price $w \in \mathbb{R}_{\geq 0}$.[24] For the sake of conciseness, we focus on situations where both downstream firms are served in equilibrium under either pricing regime. Formally, a sufficient condition for this is $F \leq \pi(k) - (1/2)\pi(0)$. For higher values of the entry cost, we would observe the usual entry promoting effect of price discrimination which in turn improves welfare.

Price discrimination.— The marginal wholesale price is set to maximize the profits from the integrated structure and thus equals upstream marginal cost, $w_I^d = w_E^d = 0$. M fully extracts the surplus with the individualized fixed fees, allowing each downstream firm just to break even. In general, with individualized fixed fees, price discrimination provides the necessary tools to perfectly disentangle the two goals of avoiding double marginalization and rent extraction.

*Uniform pricing.—*With the same two-part tariff being offered to both downstream firms, M cannot extract the generated surplus in each market via the fixed fee. The optimal marginal wholesale price, w^u, therefore balances the trade-off between efficiency and rent extraction. First, consider the case of a less efficient entrant. The common fixed fee is pinned down by the entry constraint, $T = \pi(w + k) - F$. In order to reduce the rent left to the more efficient incumbent, M optimally charges a marginal wholesale price above upstream marginal cost, $w^u > 0$. Now, suppose the entrant is more efficient. For low values of the entry cost it is not E's entry constraint but I's participation constraint that is binding, $T = \pi(w + k)$. Similar to the case of a less efficient entrant, M sets a marginal wholesale price above upstream marginal costs, $w^u > 0$, in order to reduce the rent left to the more efficient entrant. For high values of the entry cost, on the other hand, E's entry constraint imposes a binding restriction, $T = \pi(0) - F$. Here, balancing the trade-off between rent extraction and efficiency would require a marginal wholesale price below upstream marginal cost. Since a negative marginal price cannot be optimal, M charges $w^u = 0$.[25]

*Welfare.—*Uniform pricing leads to weakly higher marginal wholesale prices for all downstream firms. Thus, the quantities sold in both markets are (weakly) higher under price discrimination than under uniform pricing, which in turn implies that uniform pricing is detrimental for welfare.[26] If the entrant is less efficient or if the entry cost is low, then price discrimination is strictly welfare enhancing. For a more efficient entrant and high entry costs, marginal wholesale prices are always zero and thus welfare is the same under both pricing regimes.

The above observation seems to cast a very unfavorable light on uniform pricing. This impression, however, at least partially is rooted in our assumption of zero marginal cost upstream. If we allowed for strictly positive marginal costs upstream, for the case of a more efficient entrant and high entry costs, uniform pricing results in below marginal-cost pricing.

[24] A formal derivation of the results presented in this section is deferred to Appendix D.

[25] This statement is true only if free disposal is feasible.

[26] This finding is also obtained by Inderst and Shaffer (2009).

Since lower marginal wholesale prices for all firms translate into higher quantities sold in both markets, uniform pricing in this case improves welfare. Thus, at least for positive marginal cost upstream, there are cases where uniform pricing leads to either overall higher or overall lower marginal wholesale prices than price discrimination. In this sense, the novel pricing results identified for linear wholesale prices carry over to nonlinear wholesale contracts.

8 Downstream Competition

In this section, we allow for downstream competition with particular emphasis on a less efficient entrant.[27] Entry into the downstream industry now is not associated with the opening of a new market, but with entry into the incumbent's market. Active downstream firms produce a homogeneous good and compete in quantities. Otherwise, we stick to the sequence of events introduced in Section 3. Postponing the discussion of a more efficient entrant to the end of this section, we focus on a less efficient entrant, $k_E = k$ and $k_I = 0$, and assume linear demand, $P(q) = \max\{1 - q, 0\}$. Moreover, we restrict attention to $0 < k < 1/2$ and $0 < \sqrt{F} < 1/3 - (2/3)k =: \hat{f}^d(k)$.[28] While the first assumption guarantees that both downstream firms produce positive quantities at the optimal unrestricted uniform wholesale price, the latter rules out the case where M prefers to serve only I under both pricing regimes.

With linear wholesale contracts, M's interest in inducing entry and thereby promoting downstream competition arises from the desire to reduce double marginalization. If M nevertheless prefers to serve only one downstream firm in equilibrium, then this is always the incumbent firm.

Let $\pi(c_i, c_j)$ denote downstream firm i's gross profits when itself produces at cost c_i and its rival produces at cost c_j. As before, for low values of the entry cost,

$$\pi(w^u(k) + k, w^u(k)) \geq F \iff \sqrt{F} \leq \frac{1}{6} - \frac{7}{12}k =: \bar{f}^u(k) \tag{13}$$

under uniform pricing and

$$\pi(w^d(k) + k, w^d(0)) \geq F \iff \sqrt{F} \leq \frac{1}{6} - \frac{1}{3}k =: \bar{f}^d(k) \tag{14}$$

under price discrimination, the entry constraint does not impose a binding restriction. Note that $\bar{f}^u(k) < \bar{f}^d(k)$ because the less efficient firm receives a discount under price discrimination.

To make E enter for higher values of the entry cost, $\sqrt{F} > \bar{f}^r(k)$, M has to offer a discount wholesale price such that E can recoup its fixed cost. With competition, E's profit not only depends on its own wholesale price but also on I's wholesale price. Therefore, in contrast to the case with separate downstream markets, the restricted wholesale price at which E is just willing to enter is not necessarily identical under the two pricing regimes.

If the entry cost imposes a binding restriction, it is not always in M's interest to serve both downstream firms. Under price discrimination M prefers to implement a downstream monopoly for $\sqrt{F} \geq \hat{f}^d(k)$. Likewise, under uniform pricing M prefers I to monopolize

[27] A detailed account of the discussion of a less efficient and a more efficient entrant can be found in Appendix E and F, respectively.

[28] For illustrative reasons, all the thresholds regarding the entry cost will be expressed in terms of $\sqrt{F}$. While we denote these thresholds under downstream competition with lower case f, as before, $\bar{f}$ refers to the value of the entry cost at which M becomes restricted in it price setting, and $\hat{f}$ indicates that M does not want to serve firm E for higher entry costs. More precisely, and in analogy to the case of separate markets, these thresholds depend on both k_E and k_I. Due to cost asymmetry, however, we denote these thresholds as functions of k_E only.

the downstream market when E is very inefficient or when entry costs are high, i.e., for $\sqrt{F} \geq \hat{f}^u(k)$, where

$$\hat{f}^u(k) := \begin{cases} (1/12)[2 - 7k + \sqrt{1 - 4k + k^2}] & \text{, for } k < 2 - \sqrt{3} \\ 0 & \text{, for } k \geq 2 - \sqrt{3} \end{cases} . \tag{15}$$

Note that $\hat{f}^u(k) < \hat{f}^d(k)$. Hence, there exists a range of entry costs where entry occurs under price discrimination but not under uniform pricing, i.e., price discrimination promotes entry also when downstream firms compete. The thresholds characterized above are depicted in Figure 7.

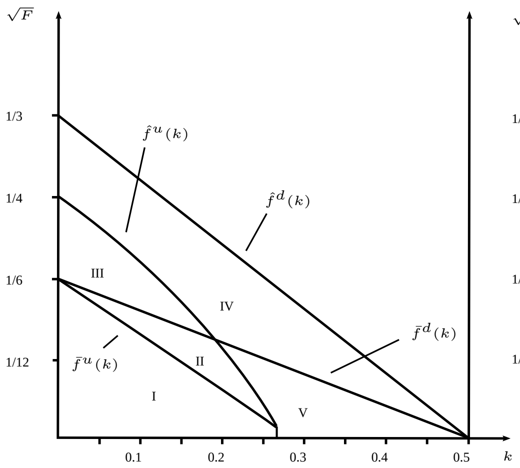

Figure 7: Market structure.

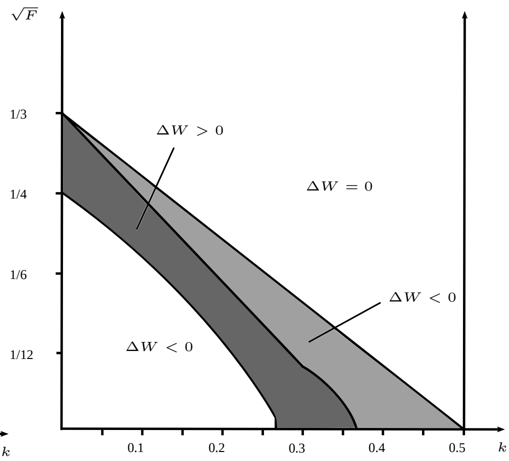

Figure 8: Welfare comparison.

Welfare.—As illustrated in Figure 7, we distinguish five cases (labeled I to V) with respect to the resulting downstream market structure. In cases I - III, where a downstream duopoly is implemented under both pricing regimes, uniform pricing improves welfare. In case III, M is restricted in his price setting under either regime. Here, price discrimination leads to overall higher wholesale prices, which implies uniform pricing to be welfare improving. In cases I and II, with M not being restricted under uniform pricing, price discrimination leads to the less efficient firm being subsidized. The resulting misallocation in production shares under price discrimination is detrimental for welfare.[29]

The more interesting cases are IV and V, where the downstream market is monopolized under uniform pricing while under price discrimination both downstream firms are active. The relatively high entry cost and/or the relatively high marginal cost of the entrant render the concession in the uniform wholesale price necessary to induce entry unprofitable. Price discrimination, on the other hand, provides M with a tool to "orchestrate" entry and to profitably implement a downstream duopoly.

For moderate values of the entry cost and a not too inefficient entrant—represented by the dark-gray shaded area in Figure 8—the entry promoting effect of price discrimination is socially desirable: society benefits from output being produced inefficiently rather than not being produced at all. If, however, the entry cost is high and/or the entrant is very inefficient—represented by the light-gray shaded area in Figure 8—entry becomes undesirable from a social perspective: while entry alleviates the quantity distortion arising under downstream monopoly, the increase in aggregate output comes at the cost of a reduction in the efficient

[29]Case I exactly corresponds to the short-run analysis in DeGraba (1990).

downstream firm's output brought about by downstream competition. With the increase in consumer surplus and M's profits being gained at the price of burdening society with the cost of entry and higher production costs, here price discrimination leads to a strictly inferior welfare outcome even though market entry is promoted—which contrasts our results for separate markets, see Proposition 1.

Defining

$$f^W(k) := \begin{cases} 1/3 - (8/9)k & \text{, for } k \leq 3/10 \\ \sqrt{(23/72)k^2 - (5/18)k + 17/288} & \text{, for } 3/10 < k \leq 17/46 \\ 0 & \text{, for } k > 17/46 \end{cases} , \tag{16}$$

we summarize the above discussion as follows:

Proposition 3: *For a less efficient entrant, $k_E = k$ and $k_I = 0$, and downstream Cournot competition, (i) $\Delta W > 0$ if $\hat{f}(k) \leq \sqrt{F} < f^W(k)$ and (ii) $\Delta W < 0$ if either $\sqrt{F} < \hat{f}(k)$ or $f^W(k) < \sqrt{F} < \tilde{f}(k)$.*

More efficient entrant.—With a more efficient entrant, $k_E = 0$ and $k_I = k$, the findings resemble the results obtained for separate markets with a more efficient entrant, as revealed by comparison of Figures 5 and 9. With regard to the following discussion, light-gray (dark-gray) shaded areas in Figure 9 indicate uniform pricing (price discrimination) to be welfare improving. For low values of the entry cost, entry occurs under both pricing regimes even for the unrestricted prices. In this case welfare is higher under uniform pricing than under price discrimination. For slightly higher values of the entry cost, $\bar{f}^d(0) < f < \bar{f}^u(0)$, M is restricted in his price setting under price discrimination but not under uniform pricing. With E not breaking even at its relatively high unrestricted discriminatory wholesale price, it is optimal for M to reduce this price in order to effectuate entry. Within this range, for relatively high entry costs $f \in (f^W(0)\bar{f}^u(0))$—and thus a relatively low discriminatory price is offered to E—welfare is higher under price discrimination than under uniform pricing. This case, in which price discrimination can lead to strictly lower wholesale prices for all downstream firms, does not exist if E is less efficient. For intermediate values of the entry cost $\bar{f}^u(0) < f < \hat{f}^u(0)$, M is restricted in its price setting under both pricing regimes. Nevertheless, it is optimal for M to serve both downstream firms under either pricing regime. In this case, for a large range of parameter values, uniform pricing leads to strictly lower wholesale prices for both firms and thus a ban on price discrimination improves welfare. For high values of the entry cost, $f \in [\hat{f}^u(0), \hat{f}^d(0))$, M prefers not to serve firm E under uniform pricing, but considers it optimal to serve both firms under price discrimination. Here, price discrimination fosters entry of a more efficient firm and this unambiguously improves welfare. Note that—in both Figure 9 and the discussion above—we restricted attention to $k \leq 1/4$ and $f \leq (1/2)(1-k)$, which are sufficient conditions for the incumbent to be served under both pricing regimes.[30]

9 Conclusion

We investigate the effects of banning third-degree price discrimination on market structure and welfare in a vertically related industry where costly entry downstream is possible.

[30] With E being more efficient and both firms operating in the same market, it can be optimal for M to effectuate entry by not serving I, thus allowing E to generate monopoly profits. With a refusal to serve an established incumbent by an upstream monopolist most likely being regarded as an abuse of a dominant position in violation of antitrust statutes, we focus on cases where the incumbent firm is served.

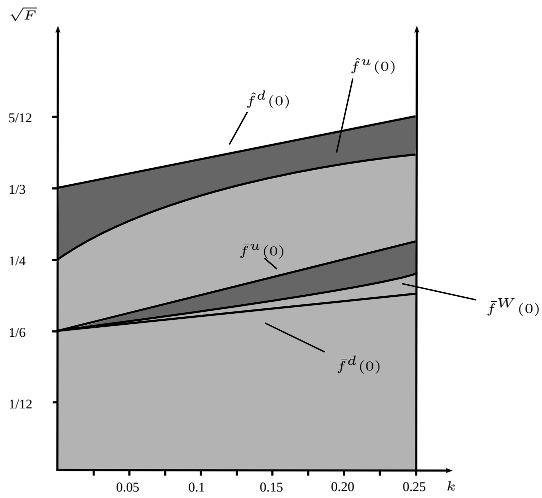

Figure 9: Downstream Competition with a more efficient entrant.

Irrespective of whether price discrimination is banned or not, for intermediate values of the entry cost, the manufacturer optimally induces entry by offering the restricted wholesale price that allows potential entrants just to break even. This gives rise to situations—in terms of the entrant's efficiency in production and the cost of entry—where price discrimination leads to either higher or lower prices for all downstream firms than uniform pricing. In these cases, with wholesale prices being clearly favorable under one of the two pricing regimes, we obtain unambiguous implications of banning price discrimination regarding welfare and consumer surplus.

If downstream firms are Cournot competitors, price discrimination has the beneficial effect that it supports entry which in turn reduces double marginalization. This beneficial effect, however, can be outweighed by entry being costly and an allocative inefficiency in production induced by discrimination against the more efficient firm.

These results are novel to the extant literature on third-degree price discrimination in intermediate-goods markets and are not to be obtained in a model of price discrimination in final-goods markets.

A PROOFS OF PROPOSITIONS AND LEMMAS

Proof of Lemma 1:
For $w_i \geq P(0) - k_i$ firm i's input demand equals zero, whereas for $w_i < P(0) - k_i$ the optimal input demand, $q(c_i)$, is strictly positive and characterized by

$$MR(q(c_i)) := q(c_i)P'(q(c_i)) + P(q(c_i)) = c_i. \tag{A.1}$$

Moreover, whenever $q(c_i) > 0$, we have $q'(c_i) < 0$, $q''(c_i) \leq 0$, $\pi'(c_i) < 0$, $MR'(q) < 0$ and $MR''(q) \leq 0$.

M's profit from charging an active downstream firm with own marginal cost $k_i < P(0)$ a wholesale price $w < P(0) - k_i$ is $\Pi(w; k_i) := wq(w + k_i)$. With $\Pi(w; k_i)$ being strictly concave on $[0, P(0) - k_i]$ the optimal unrestricted discriminatory wholesale price $w^d(k_i)$ satisfies

$$q(w^d(k_i) + k_i) + w^d(k_i)q'(w^d(k_i) + k_i) = 0. \tag{A.2}$$

We first show that $w^d(k) < w^d(0)$. Suppose, in contradiction, that $w^d(k) \geq w^d(0)$. Differentiation of (A.1) with respect to c_i yields

$$q'(c_i) = \frac{1}{2P'(q(c_i)) + q(c_i)P''(q(c_i))} = \frac{1}{MR'(q(c_i))}, \tag{A.3}$$

where the second equality follows from the definition of $MR(q)$. From (A.2) it follows that $w^d(k_i)$ satisfies

$$w^d(k_i) = -\frac{q(w^d(k_i) + k_i)}{q'(w^d(k_i) + k_i)} = -q(w^d(k_i) + k_i)MR'(q(w^d(k_i) + k_i)). \tag{A.4}$$

In consequence, $w^d(0) \leq w^d(k)$ if and only if $-q(w^d(0))MR'(q(w^d(0))) \leq -q(w^d(k) + k)MR'(q(w^d(k) + k))$. Since

$$\frac{d}{dc}\left[-q(c)MR'(q(c))\right] = -q'(c)\left[MR'(q(c)) + q(c)MR''(q(c))\right] < 0, \tag{A.5}$$

$w^d(k) \geq w^d(0)$ implies $w^d(0) \geq w^d(k) + k$, a contradiction. Hence, $w^d(k) < w^d(0)$.

We next show that $w^d(0) < w^d(k)+k$. Suppose, in contradiction, that $w^d(0) \geq w^d(k)+k$. Then $q(w^d(0)) \leq q(w^d(k) + k)$, and in consequence

$$0 > MR'(q(w^d(0))) \geq MR'(q(w^d(k) + k)) \tag{A.6}$$

by marginal revenue being decreasing and concave. From above, we know that $w^d(0) > w^d(k)$, and thus, according to (A.4), we have

$$-q(w^d(0))MR'(q(w^d(0))) > -q(w^d(k) + k)MR'(q(w^d(k) + k)). \tag{A.7}$$

Taken together (A.6) and (A.7) imply $q(w^d(k)+k) < q(w^d(0))$ and in consequence $w^d(k)+k > w^d(0)$, a contradiction. Thus, $w^d(k) + k > w^d(0)$.

When unrestricted in its price setting, M's profit from charging a uniform wholesale price w is

$$\Pi^u(w;k) := \begin{cases} \Pi(w;0) + \Pi(w;k) & \text{for} \quad w < P(0) - k \\ \Pi(w;0) & \text{for} \quad P(0) - k \leq w < P(0) \\ 0 & \text{for} \quad w \geq P(0) \end{cases},$$

Serving no firm cannot be optimal. Moreover, under Assumption (A2), it is never optimal to serve only firm I, i.e., we must have $w^u(k) < P(0) - k$. Note that $\Pi^u(w;k)$ is strictly concave on $[0, P(0) - k]$. By definition of $w^d(0)$ and $w^d(k)$, $w^d(0) > w^d(k)$ from above, and concavity of $\Pi(w;k_i)$ on $[0, P(0) - k_i]$ for $i \in \{I, E\}$, we have

$$\frac{d\Pi^u(w;k)}{dw} = \frac{d\Pi(w;0)}{dw} + \frac{d\Pi(w;k)}{dw} > 0$$

for all $w \in [0, w^d(k)]$, which immediately implies that $w^d(k) < w^u(k)$.

It remains to show that $w^u(k) < w^d(0)$. With $w^d(0) < P(0) - k$, under Assumption (A2) we have

$$\left.\frac{d\Pi^u(w;k)}{dw}\right|_{w=w^d(0)} = \left.\frac{d\Pi(w;0)}{dw}\right|_{w=w^d(0)} + \left.\frac{d\Pi(w;k)}{dw}\right|_{w=w^d(0)} = \left.\frac{d\Pi(w;k)}{dw}\right|_{w=w^d(0)} < 0,$$

where the last equality follows from definition of $w^d(0)$, and the inequality follows from $w^d(0) > w^d(k)$ and $\Pi(w;k)$ being strictly concave on $[0, P(0) - k]$. Strict concavity of $\Pi^u(w;k)$ on $[0, P(0) - k]$ then immediately implies $w^u(k) < w^d(0)$. ■

Proof of Proposition 1:
We prove part (i) first. As a preliminary consideration, consider two active downstream firms i and j with own marginal cost $k_j < k_i$. For $w < P(0) - k_i$, we have $0 < q(w+k_i) < q(w+k_j)$, and $q'(c) < 0$ for all $c \in [w+k_j, w+k_i]$. The optimal quantity demanded by a downstream firm with own marginal cost $\tilde{k} \in [k_j, k_i]$ at wholesale price w satisfies

$$P(q(w+\tilde{k})) - \tilde{k} \equiv w - q(w+\tilde{k})P'(q(w+\tilde{k})). \tag{A.8}$$

Differentiation of this expression with respect to $\tilde{k}$ yields

$$\frac{d}{d\tilde{k}}[P(q(w+\tilde{k})) - \tilde{k}] \\ = -q'(w+\tilde{k})\left[P'(q(w+\tilde{k})) + q(w+\tilde{k})P''(q(w+\tilde{k}))\right] < 0. \tag{A.9}$$

Thus, a more efficient downstream firm charges a higher mark-up.

Now, in case (i), with $F < \min\{\bar{F}^d(k), \hat{F}^u(k)\}$, we always have the optimal uniform price bracketed by the optimal discriminatory wholesale prices: for $F \leq \bar{F}^u(k)$ we have $w^d(k) < w^u(k) < w^d(0)$ by Lemma 1; for $F \in (\bar{F}^u(k), \min\{\bar{F}^d(k), \hat{F}^u(k)\})$ the optimal uniform wholesale price equals $w^R(F;k)$ where $w^R(\bar{F}^u(k);k) = w^u(k)$, $w^R(\bar{F}^d(k);k) = w^d(k)$, and $dw^R/dF < 0$. Letting q_i^d and q_i^u denote firm i's quantity under price discrimination and uniform pricing, respectively, where $i \in \{I, E\}$, this in turn implies that $q_I^d < q_I^u$ and $q_E^d > q_E^u$. Welfare under price discrimination is

$$W^d(F;k) = \int_0^{q_I^d} P(x)dx + \int_0^{q_E^d} P(x)dx - kq_E^d - F, \tag{A.10}$$

whereas welfare under uniform pricing is

$$W^u(F;k) = \int_0^{q_I^u} P(x)dx + \int_0^{q_E^u} P(x)dx - kq_E^u - F. \tag{A.11}$$

Then

$$\Delta W(F;k) = \int_{q_E^u}^{q_E^d} P(x)dx - \int_{q_I^d}^{q_I^u} P(x)dx - k(q_E^d - q_E^u) \\ < (q_E^d - q_E^u)[P(q_E^u) - k] - (q_I^u - q_I^d)P(q_I^u). \tag{A.12}$$

From (A.9) we know that $P(q_E^u) - k < P(q_I^u)$. Thus, $q_E^d - q_E^u \leq q_I^u - q_I^d$, or equivalently $Q^d(F;k) = q_I^d + q_E^d \leq q_I^u + q_E^u = Q^u(F;k)$, is a sufficient condition for $\Delta W(F;k) < 0$.

Parts (ii) and (iii) follow immediately from the reasoning in the text. ■

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