Input Price Discrimination (Bans), Entry and Welfare*

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Abstract

Recent theories by Katz 1988, DeGraba 1990, and Yoshida 2000 have identified positive effects of price discrimination bans on allocative, dynamic and productive efficiency, respectively. We show that these arguments in favor of non-discrimination rules have to be qualified, when entry into the discriminated market segment is a viable threat. We show that price discrimination ban for an upstream monopolist tends to reduce entry into the downstream market, as both the upstream monopolist and powerful downstream firms find it optimal to blockade entry for a downstream rival. By this, such a rule can hurt consumers and reduce overall welfare in a static setting. In a dynamic framework where active downstream firms decide about cost-reducing R&D expenditures, input market price discrimination can lead to larger investment activities as the entry-blockading effect of discrimination bans can exaggerate the rent extraction problem between the upstream monopolist and the innovator.

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1 Introduction

Price discrimination has long been one of the more contentious issues in industrial economics, and competition policy in particular. In order to prevent price discrimination, many countries have adopted legal price discrimination bans, which require dominant firms not to charge different buyers different prices for the same product.[1] Traditionally, the argument has been that price discrimination bans or uniform pricing rules prevent dominant firms from engaging in predatory price discrimination, which would otherwise lead to a lessening of competition in this market and, at worst, to the exclusion of rival firms from the upstream market. Accordingly, antitrust concerns have circled around the adverse effects on rival firms in the upstream market. This reasoning has been heavily criticized, for instance by Bork (1978) according to whom price discrimination is efficiency enhancing, as it allows monopolists to expand their output beyond the output level set at a uniform price. As Bork (1978, p. 397) has pointed out, price discrimination has often been discussed "as though the seller were instituting discrimination between two classes of customers he already serves, but discrimination may be a way of adding an entire category of customers he would not otherwise approach because the lower price would have spoiled his existing market." According to this line of reasoning, price discrimination is efficiency enhancing. Moreover, non-discrimination rules such as most favored customer clauses have also been identified as devices to sustain collusion between firms (see, e.g., Carlton and Perloff 2005). As a consequence, the merits of price discrimination bans have become less clear following this literature.

While traditionally most of the literature on price discrimination had focussed on final product markets (see, e.g., Varian 1989), more recently the focus has shifted towards price discrimination in input markets. Accordingly, more recent theoretical literature has started to assess the costs and benefits of non-discrimination rules by focusing on the competitive effects that price discrimination can have on downstream firms (Katz 1987, DeGraba 1990, and O'Brien and Shaffer 1994, Yoshida 2000, and O'Brien 2002), and contrasting these effects with outcomes under uniform pricing rules. Our paper is connected to this latter literature, which has derived new arguments in favor of price discrimination bans without reverting to (the difficult and still unsettled) issues of foreclosure, predatory conduct or collusive behavior. Moreover, by evaluating the relative

[1] For instance, in the US Section 2 of the Clayton Act, known as the Robinson-Patman Act due to a 1936 amendment, prohibits price discrimination that would lessen competititon. Thus a supplier that charges one firm more than another would violate Section 2 of the Clayton Act, unless they have good excuses. Acceptable excuses include that the price difference is attributable to cost differences, or that the price difference is a response to meeting competition (for an overview see Scherer and Ross 1990). In the EU discriminatory pricing is made illegal by Article 82(c) of the EC Treaty.

merits of non-discrimination rules in relation to discriminatory pricing this literature has shifted the focus of the analysis away from the delicate issue of outright "price-regulation" (e.g., in form of the Robinson-Patman Act in the US) towards the (perhaps more obvious) negative effects of price discrimination. Not too surprisingly, in the light of this new literature antitrust policies banning discriminatory pricing appear more favorable again, even for vertically separated industries.

Recently, the debate over input price discrimination has gained additional prominence especially in network industries such as airlines, telecommunications, gas and electricity, or rail transport, where a major debate circles around entry and appropriate pricing rules for access to essential facilities.[2] Almost all jurisdictions that have deregulated entry into network industries have at the same time started to regulate access to an incumbent's essential facilities in order to induce entry into downstream markets. The according access regulations, such as the European Union's Open Network Provision (ONP) almost always prescribe that access prices have to be non-discriminatory. In fact, these price discrimination bans may certainly have their merits in order to prevent vertical foreclosure if dominant firms are vertically integrated. If, however, operators are vertically separated, as it is typical for airports and airlines, ports and shipping companies and also for some other network industries in some countries, vertical foreclosure is not an issue and the merits of banning price discrimination become much less clear.

In this light, the aim of this paper is to qualify some of the propositions derived in favor of non-discriminatory pricing rules even for vertically separated industries. Broadly speaking, our point is that one should take changes in the underlying market structure into account when comparing different regulatory regimes or policies, as market structure is not independent from changes in the regulatory environment. Hence, it does not suffice to evaluate the welfare effects of a uniform pricing rule by comparing prices, sales and welfare measures for a *given* market structure. Instead, one should consider the potential effects that these rules may have on market entry and, accordingly, a market's structure in order to obtain a more complete picture.

More precisely, in our analysis we allow for the possibility of market entry at the secondary line (i.e., the discriminated downstream market side) under both a regime which allows for input price discrimination and a regime which bans input price discrimination. This approach allows us to examine the effects that different antitrust rules can have on entry. That is, market structure is not treated as exogenous in our analy-

[2] An essential facility (or monopolistic bottleneck) is the part of an incumbent's infrastructure to which access is essential for rival firms to compete in a downstream market and which is impossible or uneconomic to duplicate for rivals (i.e., because it exhibits natural monopoly characteristics). Also see Lipsky and Sidak (1999).

sis. Accordingly, we ask how input prices, innovative activity, and downstream market competition are affected, when entry is an issue, and how this affects the desirability of non-discrimination rules (or price discrimination, respectively).

For that purpose we examine a vertically separated two-tier industry with an upstream monopolist and two active downstream firms and one potential (downstream) entrant, who has a disadvantage in the sense that its price-cost-margin is smaller than the one of the two active firms. We first show that input price discrimination is generally more "entry-friendly" than non-discriminatory pricing. With uniform input prices the upstream monopolist is less likely to set an "entry-inducing" (uniform) price that would enable a disadvantaged entrant to enter the market, as this would mean lowering the (uniform) price for all downstream firms. Hence, an input price discrimination ban may blockade market entry for disadvantaged firms. In sharp contrast, discriminatory pricing leads to more downstream competition, as the input monopolist can set an entry inducing price for the new entrant without altering the price for the two incumbent firms. Hence, as input price discrimination can facilitate the entry of disadvantaged firms, input price discrimination can benefit final consumers and also enhance overall welfare.

Given this static analysis, our paper proceeds by adding the analysis of innovation incentives. This is because another prominent argument - developed by DeGraba (1990) - in favor of price discrimination bans is that uniform pricing rules can strengthen downstream firms' incentives to invest into (marginal) cost reductions. As we will show, the entry blockading effects of non-discrimination rules may also reverse this argument in favor of price discrimination; i.e. investment incentives may be larger and social welfare higher under price discrimination than under uniform pricing.

We proceed as follows: In Section 2 we review the literature which we intend to qualify with our analysis. In Section 3 we present the structure of our model before we solve for the static case in Section 4. In Section 4 we analyze the dynamic case with R&D effort. Finally, Section 5 offers concluding remarks.

2 Relation to the Literature

Rather surprisingly, the debate over input price discrimination and non-discrimination rules in vertically separated industries has so far neglected the effects on entry into the discriminated (downstream) market, even though there exists quite a bit of literature dealing with the relative merits of banning price discrimination in input markets, when entry is *not* an issue. Most important for our work are three recent papers by Katz (1987), DeGraba (1990) and Yoshida (2000), which identify particular conditions under which non-discrimination rules serve both consumers' interests and overall welfare.

Firstly, Yoshida (2000) presents a static Cournot model with linear demands, where an upstream monopolist sets input prices before downstream oligopolists choose output levels. The comparison of third-degree price discrimination and uniform pricing yields that welfare is always lower with price discrimination (see Yoshida 2000, Proposition 2). The reason is that, even though the overall output level remains unchanged, *productive efficiency* is lower under discriminatory pricing since the upstream monopolist charges less from a less efficient firm, so that the less efficient firm produces more under price discrimination than under a regime where price discrimination is not allowed.[3]

In the first part of our paper, we will show that Yoshida's result does not hold any longer once the entry blockading effects that a non-discrimination rule has are taken into account. As price discrimination induces entry for a larger set of parameter constellations, it also leads to more intense competition in the downstream segment, which generally benefits consumers and can lead to higher overall welfare levels.

Secondly, Katz (1987) has studied price-discrimination bans in a vertical structure with an input monopolist and an "asymmetric downstream duopoly," where one downstream firm can credibly threaten to integrate backward, while this outside option does not exist for the rival duopolist. In this setting, a non-discrimination rule can result in lower average input prices, and thereby, also lower output prices, as the existence of a binding outside option for one firm tends to reduce the uniform input price for all downstream firms. Hence, a price discrimination ban can increase *allocative efficiency* in this setting.

Our concern about the entry-blockading effects of price discrimination bans proves to be critical also in the case with buyer power.[4] For Katz's result to hold it is crucial that the downstream firms are equally efficient, which induces the upstream monopolist to charge a lower uniform input price so as to make the powerful buyer indifferent between accepting the proposed price or picking up its outside option. This result, however, no longer holds when we consider a disadvantaged rival in which case indifference may be achieved by a relatively high input price that blockades entry. Similar to arguments put

[3]This result only holds if it is possible to order firms according to their efficiencies. As Yoshida (2000) shows this is an issue if firms have more than one efficiency characteristic, e.g. because firms transform two inputs with two different technologies. In those cases firms cannot always be ordered unambiguously so that the above result may not hold any longer. See also Valletti (2004) who exmines how the curvature of the demand function affects Yoshida's results.

[4]As suggested by Katz (1988) we will say that that firms endowed with a binding outside option have bargaining power when compared with a situation where the upstream monopolist, who sets the input price as a take-it or leave-it offer, is unconstrained in this regard. For recent papers on buyer power see, e.g., Inderst and Wey (2005) and Marx and Shaffer (2005), and the therein cited lilterature.

forward in the literature on the anticompetitive effects of industry-wide wage contracts, a high uniform input prices can benefit powerful downstream firms by raising rivals' costs overproportionally (see Williamson 1968 and Haucap, Pauly, and Wey 2001). Consequently, the presence of powerful firms adds to our argument that price discrimination bans can unfold entry-blockading effects in a static setting, so that theories emphasizing the allocative and productive efficiency effects of such rules are reversed.

Thirdly, our paper is related to DeGraba's (1990) result that a uniform pricing rule will spur innovative efforts by downstream firms and, thereby, increase *dynamic efficiency*.[5] Intuitively, under a uniformity rule any firm's cost reduction tends to increase the (uniform) input price. However, the input price increase will be constrained under uniform pricing, as the input supplier can only increase the uniform price for all firms. Hence, the innovator can appropriate a higher rent from innovation if the input supplier is constrained in its subsequent price adjustment through a price discrimination ban. Moreover, under uniform input pricing any price increase is even more harmful for less productive rivals (that have not innovated) than for the innovator. Hence, there is a second argument why innovation incentives are stimulated under a uniform pricing rule. This is because a productivity enhancing innovation does not only lower the innovator's own costs, but also raises rivals' costs via the increase in the (uniform) input price, which makes them, ceteris paribus, less competitive in the downstream market.

Our concerns over entry are also instructive in such a dynamic environment. As input price discrimination makes it easier for a potential entrant to actually enter a market, incumbent firms may also have larger incentives to increase their productivity to improve their position, given the "threat" of entry. This is because under uniform pricing efficient firms actually benefit to some degree from the existence of disadvantaged competitors as the latter tend to lead to a compression of input prices. This, in turn, may reduce firms' innovation incentives if an innovation would lead to the disadvantaged firm's exit and, thereby, to a lower input price compression. Put differently, if an innovation would lead to higher input prices and, thereby, a more concentrated market structure under a price discrimination ban, then there are reasonable constellations under which input price discrimination would spur investment efforts, and, consequently, also both consumer surplus and aggregate social welfare.

[5] A similar point has recently been made by Banerjee and Lin (2003) who have shown that fixed price contracts can induce larger investments than floating price contracts.

3 The Analytical Framework

We consider a vertically separated two-tier industry with an upstream monopolist, M, and a downstream segment with more than one firm. We want to make our To make our results three downstream firms active incumbent firms and one potential entrant in the downstream market. The two downstream incumbents are indexed by $i = 1, 2$ and the entrant firm by $i = 3$. The upstream firm supplies an intermediate good or service to the downstream firms. Firm i's final output is denoted by q_i, and we suppose that the inverse demand for the final product is linear: $p = a - Q$, with $Q := \sum_i q_i$. Let us also assume that the upstream monopolist has a constant marginal production cost, which we normalize to zero. The final good is produced with a linear technology such that one unit of the intermediary good is needed for producing one unit of the final product. The input price, w, is the same for all buyers under a uniformity rule, while it may vary between buyers if discriminatory pricing is allowed.

The firms' attainable price-cost-margin is given by $p - k_i$ (for $i = 1, 2, 3$), where k_i includes (a) the overall marginal cost of transforming one unit of input into one unit of the final good and (b) any price discount that an entrant has to allow in order to induce consumers to buy his product. Hence, k_i consists of the input price, w_i, and the marginal production and marketing cost, MC_i, for transforming one unit of input product into one unit of the final good *and* selling it to consumers, i.e., $k_i = w_i + MC_i$. We assume that the incumbents and the entrant differ with respect to MC_i. The incumbent firms' marginal production and marketing costs are $MC_j = c$ (for $j = 1, 2$), while they are given by $MC_3 = c + \Delta$ for the potential entrant, with $0 \leq c < a$. We, therefore, suppose that the potential entrant faces an additional cost, measured by Δ. This parameter represents the incumbency advantage and may either result from additional production costs or from discounts that the entrant has to allow, e.g. because consumers may have switching costs. In the end, the source of the entrant's disadvantage is irrelevant for our analysis. What is relevant, is that the entrant has a smaller price-cost margin than the incumbents and that he is at a disadvantage compared to the two incumbents. In the rest of the paper, we assume, for the sake of simplicity, that the entrant's disadvantage results from higher production costs. Furthermore, we invoke the following assumption to ensure that, while the entrant is disadvantaged vis-à-vis the incumbent firms, he would still enter the downstream market and produce a positive quantity if the upstream segment were perfectly competitive.

Assumption 1 (A1). *Let $0 < \Delta < \widehat{\Delta}$, with $\widehat{\Delta} := (a - c)/3$, so that the entrant is strictly disadvantaged, but would produce a strictly positive quantity if the input were priced at marginal cost.*

Our analysis now proceeds in two steps: First, we analyze the "static" case without R&D investments, where the firms' production costs are exogenously given. We consider two subcases without buyer power and with buyer power, where one incumbent downstream firm has a binding outside option in the latter case but not in the former. The outside option allows the incumbent to procure the input from an alternative source at the price $w_0 > 0$. After the static case, we subsequently examine the "dynamic" case in a second step, where we assume that an incumbent firm can increase its price-cost-margin through R&D. More precisely, we assume that one firm, say firm 1, decides whether or not to undertake an innovation project, $I(\theta)$, which would increase the innovating firm's price-cost-margin by θ, with $\theta \geq 0$, at a cost of I.[6] The incentives to undertake such an innovation project are given by the firm's additional profit resulting from the implementation of the innovation. In that case the firm's price-cost-margin is given by $p - k_1$ with $k_1 = w_1 + c - \theta$.

Now let us consider the following three-stage game: In the first stage, firm 1 decides whether or not to undertake a given investment project $I(\theta)$. In the second stage, the upstream monopolist M determines his input prices, given the competition policy regime. Either discriminatory pricing is allowed (regime D) or price discrimination is banned so that prices have to be uniform across different buyers (regime U). In the third stage, the two incumbent downstream firms and the potential downstream entrant simultaneously choose their output levels. Entry is blockaded if the entrant decides not to produce anything at the posted input price(s).[7] In the dynamic regime we will analyze the entire three-stage game, while the "static case" only consists of stages two and three.

4 The Static Case

In the static case firms' production technologies and costs are exogenously given. Solving the game by backward induction we derive the sub-game perfect equilibrium outcomes. Firm i's profit function can be written as

$$\pi_i = (a - Q)q_i - k_i q_i, \text{ with } i = 1, 2, 3.$$

Given the input prices w_1, w_2, and w_3, the downstream firms compete in Cournot fashion. Depending on the relative disadvantage of the entrant firm, Δ, we have to consider two possible market structures, $\psi \in \{NE, E\}$, where $\psi = NE$ stands for the duopoly

[6] See, e.g., Bester and Petrakis (1993) for this approach. The assumption that only one firm can innovate allows us to abstract from coordination problems associated with the public good problem of entry deterrence in oligopoly (see, e.g., Bernheim, 1984).

[7] Note that we abstract from any fixed cost of entry.

structure where no entry occurs, and $\psi = E$ stands for the "entry"-case, where the entrant joins the incumbents to serve the market. Solving the firms' maximization problems results in the following optimal output levels:

$$q_i = \max\left\{0, \begin{pmatrix} (a - 3k_i + k_j + k_3)/4, & \text{if } \psi = E \\ (a - 2k_i + k_j)/3, & \text{if } \psi = NE \end{pmatrix}\right\}, \text{ and} \tag{1}$$

$$q_3 = \max\left\{0, (a - 3k_3 + k_i + k_j)/4\right\}, \text{ for } i \neq j,\ i, j = 1, 2. \tag{2}$$

With uniform input prices $w_1 = w_2 = w_3$, the entry blockading input price is given by

$$\overline{w} = a - c - 3\Delta \tag{3}$$

such that for all $w \geq \overline{w}$ the less efficient firm stays out. From (3) it follows that the less efficient firm produces a positive quantity, whenever the input is priced at marginal cost (as assumed in A1). We now partition our analysis according to the pricing regime. We denote a regulatory regime by R, with $R \in \{D, U\}$, where D stands for this discriminatory regime and U denotes the uniform pricing regime.

4.1 Discriminatory Pricing

Given the input demands derived from (1) and (2) the upstream monopolist maximizes its profits, $L_\psi^R = \sum_i w_i q_i$, by charging the monopoly input prices

$$w_i^D = (a - MC_i)/2 \text{ for } i = 1, 2, 3. \tag{4}$$

Substituting the optimal input prices into the inverse demands for the input, we obtain the equilibrium output levels

$$q_j^D = (a - c + \Delta)/8, \text{ for } j = 1, 2, \text{ and } q_3^D = (a - c - 3\Delta)/8.$$

Accordingly, total output is given by

$$Q^D = \left[3(a - c) - \Delta\right]/8.$$

Lemma 1. *The unique equilibrium market structure under the discriminatory regime D is the three-firm oligopoly,* $\psi^D = E$.

Proof. The input monopolist can either sell to all three downstream firms or restrict sales to the two efficient firms that are symmetric. If the monopolist sells to the latter two firms only (i.e., sets w_3 sufficiently large), then each incumbent duopolist produces $q_1 = q_2 = (a - c - w)/3$, and the upstream monopolist can realize maximum profits of $L_{NE}^D = (a - c)^2/6$. Selling at differentiated prices to all three downstream firms, however, secures a profit of $L_E^D = \left(3(a-c)^2 - \Delta[2(a-c) - 3\Delta]\right)/16$, which exceeds L_{NE}^D for all $\Delta < \widehat{\Delta}$. **Q.E.D.**

Note that Assumption 1 ensures that the potential entrant does not stay out of the market, but produces always a strictly positive quantity under the discriminatory regime.

4.2 Uniform Pricing

With uniform pricing, $R = U$, we have to distinguish two cases depending on whether or not the less efficient firm enters the market. That means, the upstream monopolist can either set a comparatively high uniform input price which blockades entry for the less efficient firm so that only the two downstream incumbents buy the input, or the upstream monopolist can set a comparatively low uniform input price, which induces the disadvantaged firm to enter the market so that the upstream monopolist can sell to all three firms.

Let us first consider the case where the less efficient firm is at a disadvantage so large that the upstream monopolist rather sells to the two downstream incumbents only, as the less efficient firm does not enter the market at the upstream monopolist's profit maximizing uniform input price. This input price charged to the two downstream incumbents is the same as in Equation (4), with $w_{NE}^U = (a-c)/2$, so that we obtain for firms 1 and 2 the same equilibrium output levels

$$q_{NE}^U = (a-c)/6.$$

However, the input price w_{NE}^U only blockades entry for the less efficient firm if $\Delta \geq (a-c)/6$. For $\Delta < (a-c)/6$, the upstream monopolist would have to charge the entry blockading input price $\overline{w}$ (see expression 3) in order to exclude the less efficient firm from the downstream market.

Now assume that the upstream monopolist's profit maximizing uniform input price is sufficiently small to induce the less efficient firm to enter the downstream market. Then the upstream monopolist sets the uniform input price

$$w_E^U = (a - c - \Delta/3)/2, \tag{5}$$

and the equilibrium output levels are

$$q_{j,E}^U = (a - c + 7\Delta/3)/8, \text{ for } j = 1, 2, \text{ and } q_{3,E}^U = (a - c - 17\Delta/3)/8, \tag{6}$$

so that the aggregate output level is given by

$$Q_E^U = [3(a-c) - \Delta]/8. \tag{7}$$

From Equations (6) we can see that the less efficient downstream firm only enters the market under uniform pricing for $\Delta < 3(a-c)/17$. To decide which price to set (i.e., whether to serve two or three downstream firms), the upstream monopolist will compare its profit under the two downstream market structures. Lemma 2 gives us the monopolist's optimal pricing policy and the associated equilibrium market structure when price discrimination is not allowed.

Lemma 2. *For regime U, there exists a unique threshold value $\widetilde{\Delta} = (3-2\sqrt{2})(a-c)$ such that for all $\Delta \geq \widetilde{\Delta}$ the equilibrium market structure is $\psi^U = NE$, while for all $\Delta < \widetilde{\Delta}$ the equilibrium market structure is $\psi^U = E$. Moreover, $\widetilde{\Delta} < \widehat{\Delta}$.*

Proof. We have to compare the upstream monopolist's profit depending on whether or not the less efficient entrant firm is served. With the monopoly input price given by (5) the entrant remains active for all $\Delta < 3(a-c)/17$, in which case the upstream monopoly profit becomes $L_E^U = [3(a-c)-\Delta]^2/48$. Note that the upstream monopolist's profit is strictly decreasing in Δ.

If, however, the monopolist prefers to serve only the two efficient downstream firms, then his profit maximizing input price is $w_{NE}^U = (a-c)/2$ for all $\Delta \geq (a-c)/6$. However, for all $\Delta < (a-c)/6$ the inefficient firm would purchase inputs at a price of w_{NE}^U. In those cases, therefore, the input monopolist has to charge the entry-blockading input price $\overline{w}$ if he wants to ensure that only two firms are served. Clearly, the monopoly profit at $\overline{w}$ is strictly smaller than the profit at w_{NE}^U, which is given by $L_{NE}^U(w_{NE}^U) = (a-c)^2/6$. Note that this expression is independent of Δ. Comparing L_E^U and L_{NE}^U we obtain the unique threshold value $\widetilde{\Delta} = (3-2\sqrt{2})(a-c)$, with $L_E^U < L_{NE}^U$, for all $\Delta > \widetilde{\Delta}$, and $L_E^U > L_{NE}^U$, for all $\Delta < \widetilde{\Delta}$. Note that $\widetilde{\Delta} > (a-c)/6$ so that w_{NE}^U is a feasible pricing option for the monopolist for all $\Delta > \widetilde{\Delta}$. In addition, $\widetilde{\Delta} < 3(a-c)/17$. Hence, for all $\Delta \in [\widetilde{\Delta}, 3(a-c)/17]$ the input monopolist decides to only serve the incumbent firms at w_{NE}^U even though he could also serve three firms at w_E^U. It follows that the monopolist sets the entry blockading input price, w_{NE}^U, for all $\Delta \geq \widetilde{\Delta}$, and the monopoly input price, w_E^U, with all three firms being active for all $\Delta < \widetilde{\Delta}$. **Q.E.D.**

Lemma 2 shows that the less efficient firm is excluded under a uniform input pricing regulation, whenever the potential entrant is sufficiently disadvantaged; i.e. $\Delta \geq \widetilde{\Delta}$ holds. We therefore, conclude that the discriminatory regime D tends to be more "entry-friendly" than a uniform input pricing regime.

4.3 Relative Merits of Input Price Discrimination (Bans)

Given our assumption that an entrant is disadvantaged vis-à-vis incumbent firms, banning price discrimination upstream weakens competition in the downstream market.

Under a uniformity rule the less efficient firm will only enter the market if the monopolist sets a relatively low price for *all* firms in the industry. Quite obviously, lowering the input price, compared to the price at which only the two efficient incumbents are served, is the less attractive for the upstream monopolist the more disadvantaged the entrant is. Consequently, the upstream monopolist will rather serve the two efficient firms at a relatively high price than all three firms at a lower price, unless the entrant's productive efficiency is sufficiently high.

In contrast, a discriminatory pricing regime is more "entry-friendly", as any firm that would enter the downstream market if inputs were priced at marginal cost, also enters if input price discrimination is feasible. While this difference between uniform and discriminatory pricing straightforwardly follows from the upstream monopolist's optimization problem, it also means that recent welfare assessments of non-discrimination rules are less clear-cut than has been suggested in parts of the literature. Most prominently, Yoshida (2000) has shown that in a Cournot-model with linear demands input price discrimination unambiguously causes productive inefficiencies and, thereby, a welfare loss when compared to uniform pricing.[8] However, this result does not unambiguously hold once the entry blockading effects of non-discrimination rules are taken into account, as the following proposition shows.

Proposition 1. *Comparison of social welfare and consumer surplus under regimes D and U yields the following orderings:*
(i) Social welfare: If entry is not blockaded under regime U (i.e., $\Delta < \widetilde{\Delta}$ holds with $\psi^U = E$ emerging), then social welfare is larger under regime U than under regime D. If entry does not occur under regime U (i.e., $\Delta \geq \widetilde{\Delta}$ holds with $\psi^U = NE$ emerging*), then there exists a unique threshold value, $\Delta^U > \widetilde{\Delta}$, with $\Delta^U := 31(a-c)/141$, such that social welfare is larger under regime D than under U, whenever $\Delta < \Delta^U$ holds. The opposite is true for $\Delta > \Delta^U$ (with equality at $\Delta = \Delta^U$). Moreover, $\widetilde{\Delta} < \Delta^U < \widehat{\Delta}$.*
(ii) Consumer Surplus: If entry is blockaded under regime U (i.e., $\Delta > \widetilde{\Delta}$), then consumer surpus is stricly larger under regme D than under regime U. Otherwise, consumer surplus is the same under both regimes

Proof. *Part (i):* We have to compare social welfare, W_ψ^R, (the sum of upstream and downstream producer surplus plus consumer surplus) under the two regimes $R \in \{D, U\}$. If $\Delta \geq \widetilde{\Delta}$, then $W^D - W_{NE}^U = 0$ if and only if $\Delta = \Delta^U$, and the welfare ordering then follows immediately (also see Appendix). For all $\Delta \in (0, \widetilde{\Delta})$, a comparison between W^D

[8] See Yoshida (2000, Proposition 2), where it is shown that a sufficient condition for this result is that firms can be ordered along the lines of their productive efficiency (as is the case in our setting). However, as pointed out above, Yoshida's analysis takes the number of active firms as exogenously given.

and W_E^U reveals that $W_E^U > W^D$ holds (due to the superior productive efficiency under regime U).

Part (ii): Equilibrium consumer surplus, CS^R, under the two regimes, $R \in \{D, U\}$, is proportional to total output, Q^R, with $CS^R = (Q^R)^2/2$. Comparison yields that total output (and hence consumer surplus) is always at least as large under regime D as under regime U, as $Q^D = Q_E^U = [3(a-c) - \Delta]/8$ is strictly larger than $Q_{NE}^U = (a-c)/3$ for all $\Delta < \widehat{\Delta}$. It follows that $CS^D > CS_{NE}^U$ if $\Delta > \widetilde{\Delta}$ and $CS^D = CS_E^U$ if $\Delta \leq \widetilde{\Delta}$. **Q.E.D.**

Proposition 1 shows that the entry blockading effects of input price discrimination bans, as provided for by the Robinson-Patman Act in the US and Article 82 of the European Treaty, may have damaging effects on consumer surplus and overall welfare. More generally, additional entry under price discrimination can drive down prices, which benefits consumers, while social welfare may decrease or increase, depending on the productive efficiency effects. Yoshida's finding that social welfare should decrease with price discrimination is, therefore, only valid if a price discrimination ban does not affect downstream market structure. If, however, a price discrimination ban adversely affects the dowsntream business by blockading entry, then our results show that welfare *can* be higher with a price discriminating monopolist than under a price discrimination ban. This is the more likely to be the case the relatively more efficient the entrant produces. However, the incumbency advantage between the active incumbents and the potential entrant has to be sufficiently large, as otherwise the upstream monopolist would not exclude the entrant under a uniformity rule in the first place, but serve all three firms at a lower price.

5 The Static Case with Buyer Power

This entire section is tentative and incomplete!

We now augment the above analysis by considering an outside option for the incumbent firm $i = 1$ so as to re-examine Katz's (1987) argument in favor of price discrimination bans on input markets.[9] Our main point is that his analysis neglects the potentail for substantial price increases under a non-discriminatory pricing. While in his model with symmetric downstream firms, a binding outside option can only be met by a input price reduction, we show that the contrary may also hold.

We suppose that the incumbent firm 1 has the opportunity to bypass the upstream monopolist either by producing the input inhouse or by reverting to an alternative

[9]The following is the linear version of Katz's (1987) model with the only difference that we consider asymmetric downstream firms.

supplier.[10] The remaining firms $i = 2, 3$, do not have this opportunity. In the second stage of the game, firm 1 can choose to accept the posted price or to reject it and, with this, to obtain the input from an alternative source. In the former case firm 1 pays the posted input price while in the latter case firm 1 picks up its outside option with value V_1.[11]

We now assume that the three downstream firms have the same β-efficiency while they differ with respect to their α-efficiency. Precisely, firm 1 is assumed to have an α-efficiency level of $\alpha_1 = 1$ while firms 2 and 3 are disadvantaged in this regard with $\alpha_j = \alpha > 1$ $(j = 2, 3)$.

5.1 Discriminatory Pricing

Let us assume for a moment that firm 1's outside option is not binding. As in the previous case, we solve the game by backward induction and first obtain the derived demands and then the subgame perfect input prices. We then obtain for the optimal input prices the values $w_1^{DB} = a/2$, $w_2^{DB} = w_3^{DB} = a/(2\alpha)$ (where the supescript DB stands for the discriminatory regime under buyer power). As in the previous section, the less efficient firms 2 and 3 pay a lower input price than the efficient firm 1.

Given the optimal input prices, firm 1's profits become $\pi_1^{DB} = a^2/64$, so that the outside option is strictly binding for all $V > \underline{V} := a^2/64$. Consequentlly, for all $V \leq \underline{V}$ the existence of a non-negative outside option does not constrain the monopolist's decision.

If, however, $V > \underline{V}$ holds, the outside option is binding, and the upstream monopolist must lower firm 1's input price so as to achieve indifference between accepting the posted input price and reverting to the outside option. Precisely, for $V > \underline{V}$ the solution to the upstream monopolist's problem, $\max_{w_1,w_2,w_3} L(w_1, w_2, w_3)$ subject to $\pi_1(w_1, w_2, w_3) \geq V$, can straightwardly calculted and is given

$$w_1^{DB} = 2(a - 2\sqrt{V})/3,\ w_2^{DB} = w_2^{DB} = a/(2\alpha). \tag{8}$$

Given the linear specification of our model, the monopolist's optimal response to the existence of a binding outside option is to lower the input price for firm 1, while all the

[10] There are many potential reasons why only a subset of firms may have the opportunity to bypass a monopolistic supplier. As suggested by Katz (1988) ine explanation can be that a retail chain which operates in many independent regional markets can explore economies of scale in the production of the input while local retailers are simply to small.

[11] Our main purpose is to analyze how the monopolist's price offer is affected when firm 1 has a binding outside option. We thherefore abstract from cases where the monopolist prefers to make an offer which induces the powerful downstream firm to revert to its outside option.

remaining input prices do not change.

The monopolist can match firm 1's outside option up to the integrated monopoly profit $a^2/4$ in which case firm 1's input price becomes zero. In the following, therefore, we will restrict out attention to values of the option below the maximum of industry profits; i.e., $V_1 < \overline{V}_1 := a^2/4$.[12]

Lemma 3. *Consider all values $V \in [\underline{V}^D, \overline{V}^D]$ such that the outside outside is binding. Then, firm 1's profit and social welfare is monotonically increasing in V. The outside option is matched by a input price reduction for firm 1 while the remaining input prices remain the same as in the absence of a binding outside option.*

5.2 Uniform Pricing

Under uniform pricing the optimal output levels for a given input price w can be derived as

$$q_1 = (a - w(3 - 2\alpha))/4 \text{ and } q_2 = q_3 = (a - w(2\alpha - 1))/4.$$

Inspecting these solutions, it follows that firm 2 and 3's output levels are monotonically decreasing in w, while firm 1's output may decrease or increase depending on the level of productive inefficiency, α, of firms 2 and 3. Precisely, for $\alpha < 3/2$ firm 1's profit is monotonically decreasing in w, while for larger values $\alpha > 3/2$ its profits are increasing up to the entry-blockading input price, $\overline{w}^U = a/(2\alpha - 1)$. For input prices which exceed the entry-blocking price, $\overline{w}$, firm 1's profits is, again, monotonically decreasing.

From these observations it follows immediately, that the monopolist's price-setting response to a binding outside option is either to decrease the input price (namely, if $\alpha < 3/2$ holds), or to increase the input price (namely, if $\alpha > 3/2$ holds).[13] The former reponse has been examined by Katz (1988) which has led him to conclude that a non-discrimination rule should enhance allocative efficiency. Our focus is, instead, on the latter case, where firm 1's profit is an increasing function of the uniform input price charged by the upstream monopolist.

Let us now examine the monopolst's maximization problem. Given that the outside

[12] In order to focus on the effects of an outside option on the pricing decision of the upstream monopolist, we make the simplifying assumption that the upstream monopolist always prefers the subgames where firm 1 accepts the offer. This is, we abstract from constellations where the monopolist would be better off when firm 1 rejects the offer.

[13] Note that $\pi_i = (q_i)^2$ must hold in equilibrium.

option is not binding the optimal input price is given by

$$w^U = \frac{a(1+2\alpha)}{2(2\alpha^2 + 2(\alpha-1)^2 + 1)}.$$

Firm 1's profits are then

$$\pi_1^U = \frac{9}{64}\left(\frac{a(2\alpha-1)^2}{4\alpha^2 - 4\alpha + 3}\right)^2.$$

Hence, the outside option becomes binding under non-discriminatory pricing if $V > \pi_1^U$. Under a uniformity rule the maximum profit firm 1 can obtain from the upstream monopolit is obtained at the entry-blocking input price $\overline{w}^U = a/(2\alpha - 1)$ with $\pi_1(\overline{w}^U) = (a(\alpha-1)/(2\alpha-1))^2 := \widehat{V}_1$ which is strictly smaller than $\overline{V}_1$. In the following we will focus on outside options $V_1 \in (\underline{V}_1, \widehat{V}_1)$.

Lemma 4. *Consider all values $V \in [\underline{V}^D, \overline{V}^D]$ such that the outside outside is binding. Then, firm 1's profit and social welfare is monotonically increasing in V. The outside option is matched by an input price reduction for firm 1 while the remaining input prices remain the same as in the absence of a binding outside option.*

5.3 Comparison of Pricing Regimes with Buyer Power

Assumption 2 (A2). *Under both pricing regimes the outside option, V, is binding and it can be matched by appropriate input price adjustments; i.e., $V \in [\max\{\pi_1^D, \pi_1^U\}, \min\{\pi_1^D, \pi_1^U\}]$.*

Proposition 2. *Comparison of social welfare under discriminatory and uniform pricing gives the following orderings when the outside option is always binding (i.e. Assumption 2 holds).*

i) If $\alpha < 3/2$, then $SW^U > SW^D$;

ii) If $\alpha \geq 3/2$, then there exists a unique threshold value $\widetilde{a}(\alpha)$ such that $SW^D > SW^U$ if $a > \widetilde{a}(\alpha)$, while the opposite holds if $a < \widetilde{a}(\alpha)$.

Proof. tbd

Having analyzed the merits of input price discrimination (bans) in a static framework, let us now turn to the analysis of uniform input pricing rules in a dynamic setting, as the (negative) effects of price discrimination on innovation incentives have been put forward as an important reason for disallowing input price discrimination (see DeGraba, 1990).

6 The Dynamic Case

Let us now augment the preceeding analysis by an initial stage, in which one of the two incumbents can undertake an innovation project, $I(\theta)$, which carries a fixed cost of I and increases the innovator's price-cost-margin by $\theta > 0$; e.g., by reducing marginal costs. If the innovation is realized then firm 1's price-cost-margin is $p - k_1$ with $k_1 = w_1 + c - \theta$. Subsequent to firm 1's investment decision, the upstream monopolist sets the input price(s) before downstream firms finally compete in Cournot fashion.

In the following we analyze firm 1's innovation incentives under regimes D and U. The different innovation incentives under the different regimes can be measured by the gross gain, $\Psi^R(\theta) \equiv \pi_1^R(\theta) - \pi_1^R(0)$, where the argument θ (0) indicates that the innovation has (not) been undertaken.[14]

We impose the following assumption on the maginal-cost reduction associated with the implementation of an innovation project (we maintain the assumption throughout the rest of the paper).

Assumption 3 (A3). *Let* $0 < \theta < \widehat{\theta}$ *with* $\widehat{\theta} := (\sqrt{3} - 1)(a - c)/2$*, so that the non-innovating incumbent firm remains active under both regimes D and U when the innovation project is undertaken.*

Assumption 3 is derived in the Appendix. It says that firm 1's marginal cost reduction is not so drastic that a monopoly results in the downstream market. That is, firm 1's innovation is of a kind that the non-innovating incumbent firm 2 remains active in the market under any regime.[15] The following lemma characterizes the equilibrium market structures under the two regimes for the parameter space under consideration.

Lemma 3. *The following equilibrium market structures emerge when firm 1 decides to innovate:*
(i) Regime U: If $\Delta < \Delta'$*, with* $\Delta' := \widetilde{\Delta} - \theta(\sqrt{2} - 1)$*, then* $\psi_U = E$*, while for* $\Delta \geq \Delta'$ *entry does not occur with* $\psi_U = NE$ *resulting.*
(ii) Regime D: If $\Delta < \Delta''$*, with* $\Delta'' := \widehat{\Delta} - \theta/3$*, then* $\psi_D = E$*, while for* $\Delta \geq \Delta''$ *entry does not occur and* $\psi_D = NE$ *holds.*

Note that under regime U we can distinguish two cases for $\Delta \geq \Delta'$: For $\widetilde{\Delta} \geq \Delta \geq \Delta'$ firm 1's innovation actually affects market structure, as the disadvantaged entrant only refrains from entry if firm 1 innovates, i.e. the innovation affects market structure in this case. If, however, $\Delta > \widetilde{\Delta}$, the innovation does not affect market structure, as the

[14] As mentioned above, this approach follows Bester and Petrakis (1993). Also see Boone (2000) for a comparison of different innovation incentive measures.

[15] The possibility of market monopolization under both regimes produces an obvious argument in favor of the hypothesis that innovation incentives can be larger under regime D than under U. This follows directly from inspecting our measure for innovation incentives, Ψ. A monopolizing innovation project would yield the same profit level for the innovator under both regimes. As, however, the profit level in the absence of innovation is typically lower under discriminatory pricing, it immediaty follows that innovation incentives are larger under regime D than under regime U in cases of "drastic" innovations.

entrant firm would refrain from entry even without firm 1 innovating. In the latter case, the entrant firm's disadvantage is so large that the upstram monopolist rather sells its input product to the two incumbents only. The next lemma, therefore, summarizes the effects that firm 1's innovation has on market structure.

Lemma 4. *The decision to innovate affects market structure in the following way:*
(i) Regime U: For $\Delta \in [\Delta', \widetilde{\Delta})$*, an innovation affects market structure, as it blockades entry for firm 3. For all remaining constellations the innovation does not affect market structure.*
(ii) Regime D: For $\Delta \geq \Delta''$*, an innovation affects market structure, as it blockades entry for firm 3. For* $\Delta < \Delta''$ *the innovation does not affect market structure.*

Proof. Follows from comparison of Lemmas 1-3. **Q.E.D.**

Lemma 4 shows that innovations can induce the upstream monopolist to set entry blockading input prices for firm 3, if firm 3's disadvantage is sufficiently large. Note, in this context, that $\Delta'' > \widetilde{\Delta} > \Delta'$ for all $\widehat{\theta} > \theta > 0$. That means that the scope for entry-blockading innovations is smaller under regime D (as $\Delta' < \Delta''$ holds). Only for $\Delta > \Delta''$ the innovation would also lead to a more concentrated market structure under regime D.

The analysis of the innovation incentives is now summarized in the next proposition.

Proposition 2. *(i) If the innovation does not affect the equilibrium market structure under regime U, then regime U carries larger innovation incentives than regime D: i.e.,* $\Psi^U(\theta) > \Psi^D(\theta)$ *if* $\Delta \notin [\Delta', \widetilde{\Delta})$.
(ii) If the innovation affects the equilibrium market structure under regime U (i.e. $\Delta \in [\Delta', \widetilde{\Delta})$ *holds), then there exists a critical value* $\Delta^* \in [\Delta', \widetilde{\Delta})$ *such that for all* $\Delta \in [\Delta^*, \widetilde{\Delta})$ *the innovation incentives are larger under regime D than under regime U; i.e.,* $\Psi^D(\theta) > \Psi^U(\theta)$ *if and only if* $\Delta \in [\Delta', \widetilde{\Delta})$ *and* $\Delta > \Delta^*$ *holds. In contrast, innovation incentives are larger under regime U than under regime D for* $\Delta \in [\Delta', \Delta^*]$.

Proof. See Appendix.

Proposition 2 reveals that DeGraba's result that innovation incentives are largest under a uniformity rule critically depends on the market entry consideration. More precisely, by part (i) of Proposition 2 DeGraba's result remains valid whenever an innovation does not affect market structure under regime U. The second part of Proposition 2, however, shows that this conclusion does not hold any longer when an inovation induces the upstream monopolist to increase its uniform price by so much that the potential entrant refrains from market participation. To understand the underlying logic, note that under a price discrimination ban the innovating downstream firm typically also benefits from the existence of less efficient firms in the market, as the existence of less efficient firms leads to a reduction in the uniform input price. As long as the upstream monopolist finds it optimal to serve them at a comparatively low uniform price, the innovating firm benefits from the associated mild input price increases which result from the innovation.[16] If, however, the innovation induces the input monopolist to forego the revenue stream obtained from selling to the inefficient entrant and rather to raise its uniform input price so as to increase the revenues from the two remaining firms, the price increase for the innovating firm becomes significantly larger than under a constant market structure. Moreover, the larger the potential entrant's initial exogenous disadvanatge, Δ, the more downward pressure is exerted by the entrant on input prices (as long as $\Delta < \widehat{\Delta}$). Hence, Δ has to be sufficiently large to result in lower investment incentives under uniform prices than under input price discrimination. In this case, the innovation incentives may be lower under uniform input prices than under discriminatory input prices.

The next proposition proves that under those circumstances welfare also rises.

Proposition 3. *For all $\Delta \in [\Delta^*, \widetilde{\Delta})$, welfare increases if an innovation is facilitated by regime D, but not by regime U.*

Proof. See Appendix.

As Proposition 3 reveals welfare may be increased by input price discrimination, as both market competition and innovation incentives can increase compared to a uniform pricing regime. The positive welfare effect results when an innovation takes place under regime D, but the innovation would not be implemented under regime U.

7 Conclusion

Whenever regulations are imposed on businesses, the economy is shifted from one equilibrium to another. While this clearly involves adjustments of prices and sales, it can also have substantial effects on industry structure. We have accounted for this by considering a potential entrant, and have shown that entry is less likely when price discrimination is forbidden. This entry blockading effect of uniformity regulations can have significant consequences for the assessment of their costs and benefits both within a static and a dynamic setting.

While our model has straightforward applications for vertically separated industries such as airports and ports, the model is also applicable to unionized oligopolies. As has been recently argued collective wage-setting by an industry (or even nation-wide

[16] For regme U, the input price increases by $\theta/6$ under a triopoly and by $\theta/4$ under a duopoly where entry is blockaded.

union) may have some benefits because of the positive effects that egalitarian (i.e., non-discriminatory) wage-setting may have on firms' incentives to innovate (see Haucap and Wey, 2004). If we, however, account for the entry blockading effects of those labor market regimes, then our insights may also qualify these results. More specifically, recent trends towards more flexible wage setting at the firm-level (which we interpret as some form of wage-discrimination) may unfold "entry-friendly" effects, not only in a static setting but also in a more dynamic world where cost-reduction is an important aspect of industry performance.

While we have used a fairly simple model to demonstrate that the results obtained by DeGraba (1990) and Yoshida (2000) have to be qualified once market structure is not exogenously given and entry is an issue, further research should aim at generalizing the effects of input price discrimination (bans) on market entry. For instance, one may check whether the discriminatory regime remains more "entry-friendly" under more general demand and cost functions. Is is also worthwhile to examine more general contracts, the issue of second degree price discrimination, and cases where downstream firms have bargaining power in negotiations with the upstream supplier.

Appendix

In this appendix we present proofs of lemmas and propositions which are missing in the main text. We also derive Assumptions 2 and 3.

Supplements to Proposition 1. Under price discrimination total welfare is defined by $W^D = L^D + \sum_i \pi_i^D + CS^D$, and for the linear model

$$W^D = \left(26c\Delta - 26a\Delta - 78ac + 39a^2 + 39c^2 + 47\Delta^2\right)/128.$$

Similarly, with two firms active under uniform input pricing welfare is given by $W_{NE}^U = L_{NE}^U + \sum_{i=1}^2 \pi_{i,NE}^U + CS_{NE}^U = 5\,(a-c)^2/18$. Solving $W^D - W_{NE}^U = 0$ we obtain the threshold value $\widehat{\Delta} := 31(a-c)/141$. Moreover, welfare under regime with all three firms active can be expressed as $W_E^U = [78c\Delta - 78a\Delta - 234ac + 117a^2 + 117c^2 + 269\Delta^2]/384$. The welfare comparison then yields $W^D - W_E^U = -\Delta^2/3 < 0$.

Derivation of Assumption 2. The outside option is binding when the value of the outside option is higher than the profit level under the equilibrium outcome where the upstream monopolist charges the unconstrained input prices as given by (4). Hence, $V(w_0, w_2', w_3') > \pi_1(w_1^D, w_2^D, w_3^D)$, or equivalently,

$$(3(a-c) + \Delta - 5w_0)^2/64 > (a-c+\Delta)^2/64$$

which reduces to $w_0 < \frac{2}{5}(a-c)$.

Derivation of Assumption 3. The threshold value $\widehat{\theta}$ guarantees that the the non-innovating incumbent firm 2 remains active under regime U when firm 1 undertakes the innovation project. To see this, note that the optimal input prices for given downstream market structures are given by

$$\begin{aligned} w^U(n=3) &= (a-c-(\Delta-\theta)/3)/2, \\ w^U(n=2) &= (a-c+\theta/2)/2, \\ w^U(n=1) &= (a-c+\theta)/2, \end{aligned} \tag{9}$$

from which we obtain the following output levels produced by firm 1

$$\begin{aligned} q_1^U(n=3) &= (3(a-c)+7\Delta+17\theta)/24, \\ q_1^U(n=2) &= (2(a-c)+7\theta)/12, \\ q_1^U(n=1) &= (a-c+\theta)/4. \end{aligned} \tag{10}$$

Comparison of the upstream monopolist's profits yields that $w^U(n=3)$ is optimal for all $\Delta < \Delta'$ and $\theta < \widehat{\theta}$, while $w^U(n=2)$ is optimal for all $\Delta < \Delta'$ and $\theta < \widehat{\theta}$. To this, compare $L^U(n=1)$ and $L^U(n=2)$, which are given by $L^U(n=1) = (a-c+\theta)^2/8$ and $L^U(n=2) = (2a-2c+\theta)^2/24$. As can easily be checked, $L^U(n=2) = L^U(n=1)$ if $\theta = \widehat{\theta}$. To show that it is feasible for the input monopolist to set an input price of $w^U(n=1) = (a-c+\theta)/2$ for $\theta \geq \widehat{\theta}$ without drawing demand from firm 2, note that for $n=2$ firm 2's best response is given by $q_2 = \frac{1}{3}(a-c-w-\theta)$, which is only positive for $\theta \leq (a-c)/3$. Since $\widehat{\theta} > (a-c)/3$ it is feasible and optimal for the input monopolist to charge $w^U(n=1) = (a-c+\theta)/2$ for $\theta \geq \widehat{\theta}$. Similarly, we can show by comparing $L^U(n=3)$ and $L^U(n=1)$ that $w^U(n=3)$ is feasible and optimal if and only is $\theta < \widehat{\theta}$ holds. Hence, the parameter restriction restriction $\theta < \widehat{\theta}$ assures that at least the two incumbent firms remain active under regime U when the innovation project $I(\theta)$ is implemented by firm 1.

It reamins to show that Assumption 3 assures that the non-innovating incumbent firm 2 stays active when the innovation is undertaken. For that purpose we have to compare the upstream monopolist's profit from serving only one and from serving two downstream firms under both regimes D and U. Hence, let us start and first derive the optimal production quantities and input prices under regime D. Substituting the derived demands (2) and (3) into the upstream monopolist's profit function and maximizing over the input price(s) we obtain

$$w_i^D = (a - MC_i)/2, \text{ for } i = 1, 2, 3, \tag{S1}$$

where MC_i are the firms' marginal costs given by $MC_1 = c - \theta$, $MC_2 = c$ and $MC_3 = c + \Delta$. Substituting the optimal input prices into the inverse demands for the input, we obtain the equilibrium output levels

$$\begin{aligned} q_1^D &= \tfrac{1}{8}(a-c+3\theta+\Delta), \\ q_2^D &= \tfrac{1}{8}(a-c+\Delta-\theta), \\ q_3^D &= \tfrac{1}{8}(a-c-3\Delta-\theta), \end{aligned} \tag{S2}$$

for $3\Delta+\theta<a-c$. For $3\Delta+\theta>a-c$ we receive $q_3^D=0$, and also $q_1^D=\frac{1}{6}(a-c+2\theta)$ and $q_2^D=\frac{1}{6}(a-c-\theta)$, while the input prices w_1 and w_2 remain unchanged. It is now straightforward to check that firm 2 remains active for all $\theta\le\widehat{\theta}$ and $\Delta<\widehat{\Delta}$ under regime D.

Proof of Proposition 2. Note that since the downstream firms' profits are given by $\pi_i=q_i^2$ taking into account Lemmas 1 to 4, it is straightforward to calculate firm 1's innovation incentives $\Psi^D(n_\theta,n_0)$, where the arguments n_θ and n_0 stand for the downstream market structure after and before innovation, respectively. We then obtain

$$\begin{array}{l} \Psi^D(3,3)=\frac{1}{64}\left[(a-c+\Delta+3\theta)^2-(a-c+\Delta)^2\right],\ \text{ for } \theta<a-c-3\Delta, \text{ and} \\ \Psi^D(2,3)=\frac{1}{36}(a-c+2\theta)^2-\frac{1}{64}(a-c+\Delta)^2, \text{ for } a-c>\theta\ge a-c-3\Delta. \end{array} . \tag{S3}$$

Similarly, we can calculate firm 1's innovation incentives $\Psi^U(n_\theta,n_0)$ under regime U, which are given by

$$\begin{aligned} \Psi^U(3,3) &= \tfrac{1}{576}\left[(3(a-c)+7\Delta+17\theta)^2-(3(a-c)+7\Delta)^2\right], \text{ for } \Delta<\Delta', \\ \Psi^U(2,3) &= \tfrac{1}{144}(2(a-c)+7\theta)^2-\tfrac{1}{576}(3(a-c)+7\Delta)^2, \text{ for } \widetilde{\Delta}>\Delta\ge\Delta', \\ \Psi^U(2,2) &= \tfrac{1}{36}\left[(a-c+\tfrac{7}{2}\theta)^2-(a-c)^2\right], \text{ for } \Delta\ge\widetilde{\Delta}. \end{aligned} \tag{S6}$$

We now have to pairwise compare $\Psi^U(n_\theta,n_0)$ and $\Psi^D(n_\theta,n_0)$ for $n_0=2,3$ and all $n_\theta\le n_0$ in order to prove the two parts of our proposition.

Part (i): Given that that $\Delta''>\widetilde{\Delta}>\Delta'$ for all $\widehat{\theta}>\theta>0$ we have to compare $\Psi^U(3,3)$ versus $\Psi^D(3,3)$ for the case where $\Delta<\Delta'$. In addition, we have to compare $\Psi^U(2,2)$ versus $\Psi^D(3,3)$ and $\Psi^D(2,3)$ for cases where $\Delta\ge\widetilde{\Delta}$. Firstly, note that $\Psi^U(3,3)-\Psi^D(3,3)>0$ can be rewritten as $48\theta(a-c)+184\Delta\theta+208\theta^2>0$, which is clearly always fulfilled. Secondly, we can rewrite $\Psi^U(2,2)-\Psi^D(3,3)>0$ as $58(a-c)-54\Delta+115\theta>0$. This ineqality unambiguously holds for all $\Delta<\widehat{\Delta}$ which we have assumed in A1. And thirdly, note that $\Psi^U(2,2)-\Psi^D(2,3)=0$ if

$$(48\theta+18\Delta)(a-c)-7(a-c)^2+132\theta^2+9\Delta^2=0.$$

Note that the left-hand side of this equation is increasing in Δ and that

$$\Delta^{**}:=\frac{2}{3}\sqrt{4(a-c)^2-12\theta(a-c)-33\theta^2}-(a-c)$$

is the only non-negative solution to this equation. Also note that $\Delta^{**} < \Delta''$ for all $\theta > 0$, so that $\Delta \geq \Delta''$ implies $\Delta > \Delta^{**}$and, thereby, $\Psi^U(2,2) > \Psi^D(2,3)$.

Part (ii): We proceed in four steps to show that $\Psi^D(3,3) > \Psi^U(2,3)$ *if and only if* $\Delta \in [\Delta^*, \widetilde{\Delta})$. First, let us derive Δ^*. Straght forward calculus yields that $\Psi^U(2,3) - \Psi^D(3,3) = 0$ if $(7(a-c)^2 + 58\theta(a-c) + 115\theta^2 - 42(a-c)\Delta - 49\Delta^2 - 54\Delta\theta) = 0$. Note again that the left-hand side of this equation is decreasing in Δ and that

$$\Delta^* \equiv -3(a-c)/7 - 27\theta/49 + 2\sqrt{\left(196(a-c)^2 + 994\theta(a-c) + 1591\theta^2\right)}/49$$

is the only feasible non-negative solution for the equation. Secondly, note that $\frac{d\Delta^*}{d\theta} > 0, \frac{d\widetilde{\Delta}}{d\theta} = 0, \frac{d\Delta'}{d\theta} < 0$ for all θ, and, thirdly, note that at $\theta = 0$ we obtain $\Delta'(0) = \widetilde{\Delta} > \Delta^*(0)$. Now let us define $\widehat{\widehat{\theta}}$ such that $\Delta^*(\widehat{\widehat{\theta}}) = \widetilde{\Delta}$, which holds for $\widehat{\widehat{\theta}} = (52 - 54\sqrt{2} + 4\sqrt{7376 - 5181\sqrt{2}})(a-c)/115$. Since $\widehat{\widehat{\theta}} < \widehat{\theta}$, this proves the existence of $\Delta^* \in [\Delta', \widetilde{\Delta})$.
Q.E.D.

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