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THE COMPETITIVE EFFECTS OF INPUT PRICE DISCRIMINATION UNDER HORIZONTAL SHAREHOLDING

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Abstract: Price discrimination has substantial social and policy implications and has received attention in the literature. However, prior research on input price discrimination has primarily been limited to single-input situations. We explore the strategic desirability of uniform pricing and contribute to the growing literature on perfectly complementary inputs in vertical markets. We consider a vertically related market in which two symmetric upstream firms provide perfectly complementary inputs for two downstream manufacturers, one of which has a non-controlling interest in its rival. Each upstream firm can choose between two pricing regimes: discriminatory or uniform. This study shows that although uniform pricing limits the firm's flexibility, one upstream firm voluntarily chooses uniform pricing, and the other chooses discriminatory pricing in equilibrium. Furthermore, in the mixed-strategic equilibrium for the pricing regimes, we find that downstream horizontal shareholding makes upstream firms likely to choose uniform pricing, which is undesirable for consumers and society. We extend the above analysis to the following directions: endogenous horizontal shareholding and two-part tariffs.

Keywords Uniform price · Input price discrimination · Complementary inputs · Horizontal shareholding · Self-regulation

1 Introduction

The literature on input price discrimination has focused mainly on welfare analysis and the policy implication of a ban on input price discrimination. In their seminal papers, DeGraba (1990); Katz (1987) and Yoshida (2000) show that input price discrimination has ambiguous effects on social welfare. The recent papers (Chen 2022; Choi et al. 2022; Hu et al. 2022; Li and Shuai 2022) Lestage, 2022, Lømo (2023); Matsuoka (2022) report that input price discrimination is desirable for society in many situations. In practice, some upstream firms choose uniform pricing for various goods, such as groceries, professional services, components, health supplies, equipment, motor vehicles, and so on (Shang and Cai, 2022). Yet, previous studies on input price discrimination implicitly assume that discriminatory pricing is better for an upstream firm than (self-regulatory) uniform pricing. Thus, the incentive for upstream uniform pricing has not been sufficiently analyzed. In this paper, we simply analyze this incentive, introducing perfect complementary input suppliers. We focus on the automotive industry: most products are combined with various complementary components (Asanuma 1989; Cusumano and Takeishi 1991; Laussel 2008), and horizontally competitive firms often have a small share of their rivals (Alley 1997; Elhauge 2016; Gilo et al. 2006). Our analysis shows that when a downstream firm has a non-controlling share of its rival, even if this share rate is sufficiently small,

upstream uniform pricing increases the average input price more than discriminatory pricing. Thus, although uniform pricing sacrifices price flexibility, an upstream firm has an incentive to choose uniform pricing in equilibrium. Formally, we consider a vertically related market in which two monopolistic suppliers provide each perfectly complementary input to two downstream manufacturers. One manufacturer holds the non-controlling share of the other manufacturer. At the initial stage in the pure-strategic equilibrium, each supplier can choose its own pricing regime: discriminatory or uniform. In the mixed-strategic equilibrium, each supplier chooses the likelihood of discriminatory and uniform pricing. The mixed-strategic pricing scheme is the only symmetric equilibrium, it simplifies the comparative statics, and our extensions of the model are primarily based on it. Furthermore, the mixed-strategy equilibrium can capture real-world uncertainty about the other upstream firm's pricing regime and any possible combination of uniform and discriminatory pricing. As such, the mixed-strategic equilibrium will likely be more consistent with real-world examples. We find that due to the downstream asymmetric ownership structure, self-regulatory uniform pricing raises the average input prices more than discriminatory pricing. The intuition for this is as follows. When horizontal shareholdings exist in the downstream market, the holder's rival is more aggressive than the holder. Thus, the upstream firm with discriminatory pricing sets the higher input price for the holder's rival. If the input price for the holder's rival increases, the holder increases its quantity. This implies that the upstream firm with discriminatory pricing is forced to use the less aggressive channel (the holder), which is inefficient for this upstream firm. Therefore, since the upstream firm with discriminatory pricing becomes a little reluctant to increase the input price for the holder's rival, the average input price in discriminatory pricing is lower than that in uniform pricing. This paper shows that when horizontal shareholding exists, upstream firms may voluntarily choose uniform pricing in both pure-strategic and mixed-strategic equilibrium. This result reverses our conventional wisdom that input price discrimination is better for upstream firms. Intuitively, since the average input price is higher under uniform pricing than under discriminatory pricing, upstream firms have the incentive to choose uniform pricing in equilibrium. However, upstream firms often prefer discriminatory pricing because it allows them to decide which downstream firms to trade with more primarily. By adopting uniform pricing, upstream firms give up their ability to adjust trade volumes between asymmetric buyers. Therefore, upstream firms will only adopt uniform pricing if the price-increasing effect of uniform pricing outweighs the loss of pricing flexibility. In Comparative Statics and Extension sections, we focus on the mixed-strategic pricing scheme. As a comparative static, we analyze how horizontal shareholding affects the upstream pricing schemes in the mixed-strategic equilibrium. We find that as the rate of horizontal shareholding increases, the probability of upstream uniform pricing also increases. Intuitively, horizontal shareholding exacerbates the channel inefficiency that discriminatory pricing imposes on the holder's rival and amplifies the price-increasing effect of uniform pricing. As a result, horizontal shareholding induces upstream firms to adopt uniform pricing. From a consumer perspective, we find that self-regulatory uniform pricing always undermines consumer surplus. If the input price increases, the price of the final goods also increases. Thus, since uniform pricing is a higher price commitment, it is undesirable for consumers. This analysis first demonstrates the anticompetitive

effect of voluntary compliance with a ban on price discrimination. We analyze two extensions of the mixed-strategic pricing scheme. First, we analyze endogenous horizontal shareholding, in which a downstream firm endogenously acquires the non-controlling stakes of its rival. This study shows that since horizontal shareholding reduces downstream competition, the downstream firm would hold as much of the rival's non-controlling stakes as possible in the mixed-strategy equilibrium. Second, we analyze the contract terms between upstream and downstream firms are two-part tariffs. We find that using fixed fees, at least one upstream firm forecloses the holder's rival and shares the downstream monopoly profit of the holder. Intuitively, the horizontal shareholding creates the outside option for the holder (i.e., the shared profits of the downstream rival). Thus, upstream firms would foreclose the downstream rival, not the downstream holder.

1.1 Literature review

Our study builds on the previous research on input price discrimination. The initial literature on input price discrimination (DeGraba 1990; Katz 1987; Yoshida 2000) focused on the anticompetitive effects of discriminatory pricing. These analyses suggest that the reallocation of production from efficient to inefficient firms through discriminatory pricing has an ambiguous effect on social welfare. Recent literature shows that this reallocation may be socially desirable in some situations: vertical differentiation (Chen 2017), upstream R&D (Pinopoulos 2020), price discrimination by resale markets (Miklós-Thal and Shaffer 2021), increasing marginal costs of manufacturers (Chen 2022), the sequence of contracts with retailers (Kim and Sim 2015; Choi etal. 2022), strategic inventory (Matsuoka 2022) and vertical shareholding (Lestage 2021). Hence, the antitrust legislation of the Robinson-Patman Act became controversial and is not strictly enforced (Luchs et al. 2010; Yonezawa et al. 2020). The most relevant studies on input price discrimination are those by Li and Shuai (2022) and Hu et al. (2022). They suggest that input price discrimination mitigates the anticompetitive effect of horizontal shareholding and is socially desirable. We obtain the same result qualitatively. However, the "non-discriminatory" aspect has received relatively less attention in the literature on input price discrimination. By introducing perfectly complementary inputs in the analyses of Li and Shuai (2022) and Hu et al. (2022) we examine this aspect of input price discrimination and fill this gap in the literature. We also contribute to the growing body of literature on perfectly complementary inputs in vertical markets. Laussel (2008) analyzes vertical integration by a downstream assembler under a Nash bargaining between the assembler and each supplier (subcontractor). Matsushima and Mizuno (2013) analyze a downstream firm's strategic incentive for a vertical separation to reduce external suppliers' market power. Reisinger and Tarantino (2019) analyze the effect on competition of a patent pool with nonlinear tariffs and vertical integration. The analysis of perfectly complementary inputs in a vertical market has also been applied to a variety of other topics, including conglomerate mergers (Etro 2019; Kadner-Graziano 2023; Spulber 2017), vertical foreclosure (Kitamura et al. 2018), sequential bargaining with labor unions (Chongvilaivan et al. 2013), make-or-buy decisions (Sim and Kim 2021), and downstream entry (Nariu et al. 2021). Matsushima and Mizuno (2012) and Kopel et al. (2016) only analyze input price discrimination with perfectly complementary inputs. These studies consider two types of suppliers, common and specific. Their extension section shows that a common input supplier

may choose uniform pricing endogenously. In contrast, we consider a situation where two common input suppliers can endogenously choose uniform pricing and analyze the pure-strategic and mixed-strategic pricing equilibrium. The analysis most similar to ours is the patent pool analysis by Li and Shuai (2019). Li and Shuai (2019) show that upstream firms' uniform pricing encourages manufacturers' cost-reducing investment, allowing upstream firms to set higher prices than under discriminatory pricing. Thus, uniform pricing is always the dominant strategy. In contrast, uniform pricing is not the dominant strategy in our model. Since Li and Shuai (2019) and ours analyze the incentive for perfectly complementary input suppliers to choose uniform pricing, our analysis complements (Li and Shuai 2019). The remainder of this paper is organized as follows. Section 2 describes the model. Section 3 derives the pure-strategic and mixed-strategic equilibrium outcomes. Section 4 provides comparative statics with the rate of the shareholding. Section 5 analyzes two extension models: the rate of shareholding is endogenized and the contract terms are two-part tariffs. Section 6 concludes the paper.

2 Baseline model

We consider a vertically related market with two monopolistic upstream firms and duopolistic downstream manufacturers. Each monopolistic upstream firm $k=A,B$ produces a perfectly complementary input k and sells it to manufacturer i = 1,2 . Manufacturer i produces homogeneous final goods with Leontief production technology (Etro 2019; Laussel 2008; Matsushima and Mizuno 2013). For simplicity, using one unit of each input, manufacturers produce one unit of the final product. We denote the inverse demand function $p=1-q_1-q_2$, where p is the price of the final goods, and q_i is the output of manufacturer i.

Upstream firm k sells the inputs to manufacturer i at an input price w_{ki} . We assume that the marginal cost of upstream firm k is zero. Then, these firms' profits are as follows:

$\pi A = wA1q1 + wA2q2$, $\pi B = wB1q1 + wB2q2$. (1)

Each upstream firm can commit to employing uniform pricing for the input. With this commitment, upstream firm k charges an equal input price w_{kU} $(= w_{k1} = w_{k2})$ to both manufacturers. Without this commitment, it charges w_{k1} to manufacturer 1 and w_{k2} to manufacturer 2.

The operating profit of the manufacturer i is $\pi_i = (p-w_{Ai}-w_{Bi})q_i$, assuming that their marginal production cost is zero. We consider that manufacturer 2 owns $r\times100\%$ of the non-controlling share of firm 1, where r is the degree of horizontal shareholding ($0< r <1/2$) . Then, the total value function for each manufacturer is :

$V_1 = (1-r)_1$, $V_2 = r\pi_1+\pi_2$. (2)

We assume that the manufacturers compete on quantity to maximize their total values. If r converges to 1/2, the downstream shareholder (firm 2) has a greater incentive to decrease its quantity to increase the profit of the downstream rival (firm 1). Thus, the downstream competition is alleviated. If r converges to 0, there is no such incentive. Hence, the downstream competition becomes as fierce as the standard Cournot competition. We denote consumer surplus and social welfare by

$CS = (q_1+q_2)^2/2$ and $SW = CS+\pi_1+\pi_2+\pi_A+\pi_B$, respectively.

The timing of the game is as follows: In stage 1, upstream firm k chooses their pricing regime: discriminatory (D) or uniform (U). In stage 2, upstream firm k sets the input prices w_{ki} . In stage 3, downstream firm i chooses its output to maximize its total value. We solve the game using backward induction.

3 Analysis

3.1 Downstream quantity competition

First, we derive the outcomes of the third stage. From the first-order conditions, $\partial V_i/\partial q_i = 0$, we obtain the following outputs:

$$q_1(w_{A1},w_{A2},w_{B1},w_{B2}) = \frac{1 - 2w_{A1} - 2w_{B1} + w_{A2} + w_{B2}}{3 - r},$$

$$(3)\ q_2(w_{A1},w_{A2},w_{B1},w_{B2}) = \frac{1 - r - 2w_{A2} - 2w_{B2} + (1 + r)(w_{A1} + w_{B1})}{3 - r}.$$

Focusing on $q_1(w_{A1},w_{A2},w_{B1},w_{B2})$ and $q_2(w_{A1},w_{A2},w_{B1},w_{B2})$, we confirm the following two effects. First, horizontal shareholding makes the holder less aggressive in producing. We can find this effect at $1-r$ in the numerator of $q_2(w_{A1},w_{A2},w_{B1},w_{B2})$. This effect, called *competition effect*, is well-known in the previous literature. Second, if the input price for the holder's rival w_{k1} increases, the shared profit $r\pi_1$ will decrease, and thus the holder will focus on the operating profit π_2 , thereby increasing its own quantity. We can confirm this effect at $(1+r)(w_{A1} + w_{B1})$ in the numerator of $q_2(w_{A1},w_{A2},w_{B1},w_{B2})$. This effect, called *production reallocation effect*, is a new effect derived from perfectly complementary inputs.

3.2 Input price decision

Based on the decision in the first stage, we have three subgames: (i) both upstream firms perform input price discrimination (case D), (ii) both upstream firms employ uniform pricing (case U), and (iii) one upstream firm takes a uniform price commitment, and the other does not (case P).

3.2.1 Case D: discrimination by both upstream firms

First, we consider the case D in which both upstream firms adopt discriminatory pricing. We obtain the following input price by solving the first-order condition for w_{ki}.

$$w_{DA1} = w_{DB1} = \frac{27 - 9r - 2r^2}{9 - 4r}, \quad (4)$$

$$w_{DA2} = w_{DB2} = \frac{27 - 9r - 2r^2}{9 - 4r},$$

where the superscript D represents price discrimination by both upstream firms. The downstream profits π_1^D and π_2^D , upstream profits π_A^D and π_B^D , consumer surplus CS^D , and social welfare SW^D in stage 2 are summarized in Appendix A.1.

3.2.2 Case U: no discrimination

Next, we analyze the case in which each upstream firm k makes a uniform price commitment; we impose conditions $w_{A1} = w_{A2} \equiv w_A$ and $w_{B1} = w_{B2} \equiv w_B$. Substi-

tuting $q_i(w_A,w_A,w_B,w_B)$ into π_k and solving the first-order conditions for w_{kU} , we obtain the following input price:

$w^U_{kU}=\frac{1}{3}$, $k=A,B$, (5)

where the superscript U represents the non-discriminatory pricing case. The downstream profits π_1^U and π_2^U , upstream profits π_A^U and π_B^U , consumer surplus CS^U , and social welfare SW^U in stage 2 are summarized in Appendix A.1.

3.2.3 Case P: partial discrimination

Finally, we consider the case in which firm $k=A,B$ chooses discriminatory pricing, and firm $l = A,B$ ($l \neq k$) commits to choosing uniform pricing in stage 1. By solving the first-order conditions for w_{ki} and w_{lU} , we obtain the following input price:

$wk\ P1 = (2 - r)(3 + r2)$, $wPk2 =$ [1][2][3]$-(26-r-r)\ r2$

$P\ wDk1 + wDk2$ $U\ wPk1 + wP\ k2\ wlU >$, $wkU >$. 2 2

Proof See Appendix A.2.

The intuition for the inequality in Lemma 1 is as follows. Since the holder's rival (firm 1) is more aggressive than the holder (firm 2), upstream firm k with discriminatory pricing sets the higher input price for the holder's rival. Due to *production reallocation effect* $(1+r)(w_{A1}+w_{B1})$ in the numerator of $q_2(w_{A1},w_{A2},w_{B1},w_{B2})$, if the input price for the holder's rival w_{k1} increases, the holder focuses on its operating profit π_2 , thereby increasing its quantity q_2 . Thus, *production reallocation effect* prevents upstream firm k from increasing w_{k1} , and the selling channel through the holder's rival (firm 1) becomes inefficient. Conversely, *production reallocation effect* does not directly influence w_{k2} ; thus, the selling channel through the holder (firm 2) does not change. Therefore, upstream k has difficulty setting a high price for the large market (firm 1); the average input price is higher under uniform pricing than under discriminatory pricing. □

[1] $-6r-r$

[2] .**2.4 Effect of uniform pricing**

Here, we summarize the effect of choosing the self-regulating uniform pricing. Comparing the average input prices in each case, we obtain the following Lemma:

Lemma 1 *When a downstream firm holds its rival's shares, if an upstream firm switches the pricing regime from discriminatory to uniform, its average input price will increase*:

[3] $2(3-r)$, $k,l = A,B,k \neq l$, (6) $wlU = 18 - 6r - r2$

where the superscript P represents the case of partial discrimination. The downstream profits π_1^P and π_2^P , upstream profits π_k^P and π_l^P , consumer surplus CS^P , and social welfare SW^P in stage 2 are summarized in Appendix A.1.

3.3 Pricing scheme

In stage 1, upstream firm k chooses its pricing regime: discriminatory (D) or uniform (U). Since, as we will show later, our model has two pure-strategic equilibria, our model also has a mixed-strategic equilibrium. In section 3.3.1, we summarize the results in the pure-strategic pricing strategy. In section 3.3.2, we summarize the results for the mixed-strategic pricing strategy.

3.3.1 Pure-strategic equilibriua

Here, we summarize the two pure-strategic equilibria in our model. Comparing the profits of the upstream firms in each case, we obtain the following result:

Proposition 1 *When a downstream firm holds its rival's shares* (*for any* $r > 0$), *one upstream firm chooses uniform pricing*, *and the other chooses discriminatory pricing in equilibrium*.

Proof See Appendix A.2.

This proposition suggests that when horizontal shareholding exists, the asymmetric equilibrium of the pricing regime is always realized. Sacrificing pricing flexibility, one of the symmetric upstream firms chooses uniform pricing. This result contrasts with Li and Shuai (2019), where all upstream firms commit to choosing uniform pricing in equilibrium.

An intuition behind this result is as follows. Lemma 1 implies that switching from discriminatory pricing to uniform pricing increases the switcher's average input price. Furthermore, input complementarity decreases the other's average input price. Thus, more than one upstream firm chooses uniform pricing, and case D is not an equilibrium outcome.

In our model, uniform pricing by both upstream firms raises the input prices too much; if both firms choose uniform pricing, their profits will be lower than those in the asymmetric pricing equilibrium. Therefore, case U is not an equilibrium, and
case P is always realized in equilibrium. □

3.3.2 Mixed-strategic equilibrium

Next, we summarize the outcome of the mixed-strategic pricing scheme. We define the upstream firm j's choosing probabilities of discriminatory pricing and uniform pricing as θ_j and $1-\theta_j$, respectively. Considering the mixed-strategic equilibrium, in stage 1, upstream firm j chooses θ_j to maximize its own profits.

In the equilibrium, given the other upstream firm's mixed strategy, upstream firm j has no incentive to deviate. Thus, since the upstream firms are symmetric, the equilibrium mixed-strategy θ^* is the solution of the following equation:

$$\theta^* \pi_j D + (1-\theta^*)\pi_k P = \theta^* \pi_l P + (1-\theta^*)\pi_j U$$

$$\theta^* = \frac{5t_4 + 5At_3 - \partial t_5 - 3\Sigma 8t_1 + 2\partial\Gamma}{(t_5 + 3t_1 - \partial)(5t_5 + \partial t_1 - 5\Gamma)} \tag{7}$$

$\Leftrightarrow \theta$.

Therefore, we obtain the following proposition:

Proposition 2 *When a downstream firm holds its rival's shares* (*for any* $r>0$), *there is the unique mixed-strategic equilibrium of pricing scheme where both upstream firms choose discriminatory pricing at probability* $\theta^* = \frac{(r^2+3r-9)(2r^2+9r-27)}{2r^4+24r^3-9r^2-378r+567}$.

The intuition of this result is as follows. Lemma 1 suggests that upstream firms can increase their input price by uniform pricing, and Proposition 1 suggests that the best response to uniform pricing is discriminatory pricing. Thus, upstream firms have the incentive to mix their pricing scheme.

4 Comparative statics

As shown below, the mixed strategic equilibrium is essential for analyzing the effect of horizontal shareholding on the pricing decisions. It is the only symmetric equilibrium that encompasses all possible combinations of uniform and discriminatory pricing, while highlighting the uncertainty that each upstream firm faces regarding the other's pricing regime. Because of these rich properties, we mainly focus on the mixed strategic equilibrium in this section.

4.1 Uniform pricing

First, we investigate the effect of horizontal shareholding on the upstream pricing scheme. We can confirm that, in contrast to the pure-strategic equilibria, upstream firms' pricing schemes depend on the degree of downstream horizontal shareholding. Thus, we obtain the following proposition:

Proposition 3 *Upstream firms are more likely to adopt uniform pricing as r increases. Formally,* $\partial\theta^*/\partial r<0$.

Proof See Appendix A.2.

This result suggests that the degree of horizontal shareholding affects the upstream pricing scheme. Previous literature on input price discrimination by a single input supplier would not have seamlessly captured the pricing scheme change. Our mixed-strategy pricing scheme model captures this seamless change for the first time. Intuitively, since horizontal shareholding reduces downstream competition and becomes close to downstream monopoly, upstream firms would set higher input prices using uniform pricing. Therefore, upstream firms are more likely to adopt uniform pricing as the degree of horizontal shareholding increases. □

4.2 Welfare

Next, we investigate the effect of the horizontal shareholding on the welfare. In the mixed-strategic equilibrium, the consumer surplus $CS^M = \theta^{*2}CS^D + 2\theta^*(1-\theta^*)CS^P + (1-\theta^*)^2CS^U$ and social welfare $SW^M = \theta^{*2}SW^D + 2\theta^*(1-\theta^*)SW^P + (1-\theta^*)^2SW^U$. The outcome of CS^M and SW^M is relegated to Appendix A.2.

As the pure-strategic equilibria, the consumer surplus and social welfare depend on the degree of downstream horizontal shareholding: $\partial CS^M/\partial r<0$ and $\partial SW^M/\partial r<0$. We summarize the results of the welfare analysis as follows:

Proposition 4 *Consumer surplus and social welfare decrease as r increases.*

Proof See Appendix A.2.

This result suggests that horizontal shareholding induces upstream uniform pricing. Intuitively, since horizontal shareholding alleviates downstream competition and increases the probability of adopting

uniform pricing, it is undesirable for consumers and society. Note that, from simple comparison, we obtain $CS^D > CS^P > CS^U$ and $SW^D > SW^P > SW^U$ in the pure-strategic equilibria. This result implies that the selfregulatory uniform pricing harms consumers and society. This result is in stark contrast to Li and Shuai (2019): Self-regulatory uniform pricing always benefits consumers and society.

5 Extension

5.1 Endogenous horizontal shareholding

This section analyzes the downstream firm's incentive to acquire the rival's noncontrolling stakes. The stages are as follows. In stage 0, the downstream firm 1 decides how much the non-controlling shareholding rate r is. Downstream firms distribute firm 2's profit according to this shareholding rate by some monetary transfer, such as a fixed fee. Here, we do not analyze how to distribute the profit, and we assume that the downstream firm 1 chooses the optimal shareholding rate to maximize the downstream joint profit $\Pi^M_{12}(r) = \pi_1^M + \pi_2^M$. The following stages, from 1 to 3, are the same as the baseline model. As the comparative statics in Sect. 4, we mainly focus on the mixed-strategic equilibrium.

Upstream firms choose uniform pricing with probability θ^* in the mixed strategic equilibrium. Differentiating $\Pi^M_{12}(r)$ with respect to r, we obtain $\partial \Pi^M_{12}(r)/\partial r > 0$. Thus, we obtain the following proposition:

Proposition 5 *Even in the mixed-strategic equilibrium, since the downstream joint profit increases in r, the downstream firm would hold as much of the rival's noncontrolling stakes as possible.*

Proof See Appendix A.2.

This result shows that the incentive to hold the rival's share remains in the mixedstrategic equilibrium. The intuition is straightforward: holding the rival's share
could alleviate the downstream competition. □

5.2 Two-part tariff

Here, we consider that both upstream firms contract is two-part tariff $T_{ki} = (w_{ki}, F_{ki})$, where w_{ki} is k's linear price and $F_{ki} \in [0,\infty)$ is k's fixed fee to the downstream firm i. Both downstream firms decide whether to accept or reject after observing the two-part tariffs. For simplicity, we focus on the symmetric equilibrium. We show that each upstream firm sets the marginal cost pricing and fixed fee that evenly shares the downstream monopoly profit π_M , the maximum profit that downstream firms can earn. Due to horizontal shareholding, the holder's rival must transfer part of its profits. Hence, if it accepts this symmetric two-part tariff, it would end up with negative profits. Thus, the rival rejects this tariff. In contrast, if the holder accepts, it could pay this fixed fee, and its profit becomes zero. Therefore, only the holder is willing to accept the tariff, and the holder's rival is excluded from the market. Note that without downstream horizontal shareholding, this symmetric offer would not foreclose the rival, underscoring the crucial role of horizontal shareholding in market foreclosure. Based on this reasoning, we obtain the following Proposition:

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Proposition 6 *When a downstream firm holds its rival's shares and upstream firms' contracts are two-part tariffs,* (*i*) *an equilibrium tariff is* $T_{ki}^* = (0, \pi_M/2)$, (*ii*) *upstream firms foreclose the holder's rival.*

Proof See Appendix A.2.

This result suggests that the two-part tariffs monopolize the downstream market. Even if the upstream firm adopts discriminatory pricing, the exclusion of the holder's rival leads it to offer the same contract to both downstream firms. In this sense, uniform pricing and discriminatory pricing effectively become the same.

6 Conclusion

The literature on input price discrimination typically focuses on single-input situations. To shed light on the strategic desirability of upstream uniform pricing, we build a model based on two perfectly complementary inputs in which upstream firms choose pricing schemes: discriminatory or uniform. Using a linear inverse demand function under downstream asymmetries of horizontal ownership structure, we find that, because of discriminatory pricing's channel inefficiency of the downstream firm whose share is held by the rival, if an upstream firm chooses uniform pricing, this firm increases its total input price. Thus, uniform pricing is the optimal strategy for an upstream firm. Furthermore, considering the mixed-strategic pricing scheme, we find that downstream horizontal shareholding induces upstream uniform pricing, which is detrimental to the consumer and society.

A Appendix

A.1 Subgame outcomes in stage 2

Case D: Discrimination by both upstream firms

$\pi 1D = \overline{(27(-39-r2-r)22r2)2} \quad 2D \quad (3\,(-27r)-(39+r\,-2r2-r22)\,2r2)$, $\pi D = \pi BD = 27\,-29-r\,-r$

$\_\_\_\_\_ \quad \_\_\_\_\_ \quad 2r2,$

$, \pi = \quad A$

$\_\_\_\_\_$

$9(2\,-r)^2 \qquad 3(2\,-r)(48\,-15r\,-4r^2)$

$CS_D = \quad , SWD = \qquad . 2(27\,-9r\,-2r^2)^2 \quad 2(27\,-9r\,-2r^2)^2$

Case U: No discrimination

$\pi U \;=\; (\,2\,-r)2 \qquad U \qquad (2\,-r)2(1\,+r)$, $\pi U = \pi U = (2\,-r)2$,

$, \pi =$

$\_\_\_\_\_$

$\_\_\_\_\_$

$\_\_\_\_\_$

$1\,(4\,-6r\,-r^2)2 \qquad 2 \qquad (18\,-6r\,-r^2)\,2 \qquad A \qquad B \qquad 9(3\,-r)2$

$CS^U = (\,2\,-r)2$, $SWU = \frac{(2\,-r)(16\,-5r)}{18(3\,-r)^2}$.

Case P: Partial discrimination

[4] $(3\,-r)^2$

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$$\pi_1^P = \frac{(2-r)^2}{(18-6r-r^2)}, \quad \pi_2^P = \frac{(2-r)^2(1+r)}{(18-6r-r^2)}, \quad SW^P = \frac{2(2-r)(16-5r-r^2)}{(18-6r-r^2)^2}.$$

$$CS^P = \frac{2(2-r)^2}{(18-6r-r^2)^2}, \quad \pi^P = k\,(18-6r-r^2), \quad \pi_l^P = \frac{4(2-r)(3-r)}{(18-6r-r^2)^2},$$

A.2 Proof

In this section, as in the text, when we consider the partial discrimination case (case *P*), we denote *k* as the upstream firm that chooses discriminatory pricing and *l* as the one that chooses uniform pricing. Here, we prove Lemma 1, Proposition 1, Proposition 3, Proposition 4, Proposition 5, and Proposition 6. Note that the proof of Proposition 2 is in the text.

Proof of Lemma 1 By comparing (4), (5), and (6) for any $k,l=\{A,B\}, k \neq l$, we have

$$PDD \Leftrightarrow (6+r)(2-r)r^2 > 0, \quad 2w_l U - (w_{k1}+w_{k2}) = \frac{(18-6r-r^2)(27-9r-2r^2)}{r^2} > 0.$$

□

Proof of Proposition 1 To analyze the incentive to deviate, we calculate the upstream firm's best response to the other firm's pure-strategic pricing regime. First, we investigate the incentive to change its pricing regime and deviate from case *D* to case *P*:

$$\pi_k^P - \pi_k^D = \frac{(2-r)^2(6+r)r^2}{(18-6r-r^2)^2(27-9r-2r^2)} \geq 0.$$

Thus, when an upstream firm chooses discriminatory pricing, the other upstream firm will choose uniform pricing.

Next, we investigate the incentive to change its pricing regime and deviate from case *U* to case *P*:

$$\pi_k^P - \pi_k^U = -\frac{(2-r)(9-3r-r^2)r^2}{9(3-r)(18-6r-r^2)^2} \geq 0.$$

Thus, when an upstream firm chooses uniform pricing, the other upstream firm will choose discriminatory pricing. Therefore, in the pure-strategic equilibria, one upstream firm chooses discriminatory pricing, and the other chooses uniform pricing. □ ***Proof of Proposition 3*** The partial derivative of θ^* with respect to *r* is

$$\frac{\partial \theta^*}{\partial r} = -\frac{9r(6-r)\left(2r^4+16r^3-15r^2-198r+297\right)}{\left(2r^4+24r^3-9r^2-378r+567\right)^2} < 0.$$

Therefore, upstream firms are more likely to adopt uniform pricing as *r* increases.

Proof of Proposition 4 In the mixed-strategic equilibrium, the consumer sur-

plus $CS^M \equiv \theta^{*2} CS^D + 2\theta^*(1-\theta^*) CS^P + (1-\theta^*)^2 CS^U$ and social welfare $SW^M \equiv \theta^{*2} SW^D + 2\theta^*(1-\theta^*) SW^P + (1-\theta^*)^2 SW^U$ is

$$CS^M = \frac{9(2-r)^2 \Omega_{CS}}{2(r^2+6r-18)^2(2r^4+24r^3-9r^2-378r+567)^2},$$

$$SWM = \frac{3(2-r)\Omega_{SW}}{(r^2+6r-18)^2(2r^4+24r^3-9r^2-378r+567)^2},$$

where the definitions of $\Omega_{CS}(>0)$ and $\Omega_{SW}(>0)$ are relegated to Appendix A.3.

The consumer surplus and social welfare depend on the degree of downstream horizontal shareholding:

$$\frac{\partial CS^M}{\partial r} = -\frac{9(2-r)\omega_{CS}}{(18-6r-r^2)^3(2r^4+24r^3-9r^2-378r+567)^3} < 0,$$

$$\frac{\partial SWM}{\partial r} = -\frac{\omega_{SW}}{(18-6r-r^2)^3(2r^4+24r^3-9r^2-378r+567)^3} < 0,$$

where the definitions of $\omega_{CS}(>0)$ and $\omega_{SW}(>0)$ are also relegated to Appendix A.3. □

Proof of Proposition 5 The derivative of $\Pi^M{}_{12}(r)$ by r is

$$\frac{\partial \Pi M12(r)}{\partial r} = \frac{\phi_M}{(18-6r-r^2)^2(567-378r-9r^2+24r^3+2r^4)^2} > 0,$$

where the definition of $\phi_M(>0)$ is relegated to Appendix A.3. □

Proof of Proposition 6 We first prove the result (*ii*). The maximum profit that downstream firms can obtain is the monopoly profit π_M. However, the holder's rival must give some of its profit through horizontal shareholding. Hence, when the sum of the fixed fees is equal to the monopoly profit π_M, the rival's profit will be negative even if it monopolises the market. Therefore, the holder's rival never accepts the symmetric two-part tariff contract. In contrast, if the holder monopolizes the market, it can pay this fixed fee, and its profit becomes zero. Hence, under the equilibrium offer $T_{ki}^* = (0, M/2)$, only the holder will accept the symmetric two-part tariff contract, and the holder's rival is excluded from the market. Next, we prove the result (*i*). We show that (symmetric) upstream firms have no incentive to deviate from the equilibrium offer $T_{ki}^* = (0, M/2)$. Under this offer, the holder's rival is foreclosed, and both upstream firms obtain half of the downstream monopoly profit. If an upstream firm sets a high

input price or fixed fee for the downstream holder, the holder's profit becomes negative, thus rejecting this offer. Hence, this rejected offer makes the upstream firm's profits zero. Thus, this upstream firm never set a high input price or fixed fee for the downstream holder. If an upstream firm sets the low input price or fixed fee, the holder still obtains the monopoly profits and thus accepts this offer. However, since this offer indeed reduces this upstream firm's profit, such a deviation never occurs. Therefore, the offer $T_{ki}^* = (0, M/2)$ is an equilibrium outcome, and the holder's rival is foreclosed in this equilibrium. □

A. 3 The relegated values

The Values of Ω_{CS} and Ω_{SW} in Proof of Proposition 4

$\Omega_{CS} \equiv 142884 - 190512r + 54756r^2 + 19332r^3$
$- 7695r^4 - 1194r^5 + 287r^6 + 54r^7 + 2r^8 (> 0)$, $\Omega_{SW} \equiv 3000564 - 4858056r + 2135484r^2 + 287388r^3 - 336879r^4 - 1260r^5 + 21885r^6 + 780r^7 - 612r^8 - 72r^9 - 2r^{10} (> 0)$.

The Values of ω_{CS} and ω_{SW} in Proof of Proposition 4

$$\omega_{CS} \equiv 486091368 - 1210268304r + 1139173308r^2 - 422082252r^3 - 38784258r^4$$
$+ 77157360r^5 - 14495193r^6 - 4236057r^7 + 1498743r^8 + 118512r^9 - 64842r^{10} - 4131r^{11} + 1238r^{12} + 146r^{13} + 4r^{14} (> 0)$,
$\omega_{SW} \equiv 21874111560 - 58836895992r + 60548136012r^2 - 24841678104r^3$
$- 2643072606r^4 + 5964382026r^5 - 1385750997r^6 - 395839710r^7 + 193594698r^8 + 8009928r^9 - 11891961r^{10} - 7560r^{11} + 411948r^{12} + 12024r^{13} - 6642r^{14} - 600r^{15} - 12r^{16} (> 0)$.

The Value of ϕ_M in Proof of Proposition 5

$$\phi_M \equiv 2571912 - 4715172r + 2280312r^2 + 624996r^3$$
$- 752814r^4 + 70605r^5 + 67590r^6$
$- 9765r^7 - 2988r^8 + 270r^9 + 68r^{10} + 2r^{11} (> 0)$.

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