Input Price Discrimination with Bundling

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Input Price Discrimination with Bundling*

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Abstract

This paper examines how bundling affects the welfare comparison between input price discrimination (IPD) and uniform input pricing (UIP) in a vertical market structure with Cournot competition. A multi-product firm bundles its products across a competitive market and a monopoly market, while an upstream supplier provides inputs only to the competitive market. When the inefficient firm is the bundling firm, IPD can increase total surplus relative to UIP if the monopoly market is sufficiently small. When the efficient firm is the bundling firm, however, IPD always reduces both consumer and total surpluses.

JEL codes: D43, L10, L13

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1 Introduction

It is well known that input price discrimination (IPD) harms welfare compared with uniform input pricing (UIP), since IPD reallocates production from efficient to inefficient firms by setting a higher input price for the efficient downstream firm and a lower input price for the inefficient one (DeGraba, 1990; Yoshida, 2000). Recent work shows that IPD can be welfare-enhancing in various contexts (Arya and Mittendorf, 2010; Gaudin and Lestage, 2022; Hu et al., 2022; Li and Shuai, 2022; Lømo, 2023). We challenge this conventional wisdom by considering the existence of bundling.

We consider a vertical structure where a multi-product firm bundles its products across a competitive market and a monopoly market, while an upstream supplier provides inputs *only* to the competitive market. In the competitive market, the downstream firms differ in efficiency. We find that bundling creates a clear and robust input price ranking under IPD: the bundling firm always faces a higher input price than under UIP, while the rival firm faces a lower input price. This ranking holds regardless of which firm is efficient, because the bundling firm's monopoly profit makes it less sensitive to input price increases. Importantly, we find that when the inefficient firm is the bundling firm, IPD can increase total surplus if the monopoly market is sufficiently small, which reverses the conventional wisdom mentioned above. However, when the efficient firm is the bundling firm, IPD always reduces welfare.

Our paper is related to Arya and Mittendorf (2010), who also consider a two-market setting with an upstream supplier. However, there are important differences. In Arya and Mittendorf (2010), the upstream supplier provides inputs to both markets, so the two markets are linked through input pricing even without bundling. In our model, the upstream supplier serves *only* the competitive market; without bundling, the monopoly market is independent and IPD always reduces total surplus. Moreover, in their model the multi-market firm chooses quantities separately in each market (only the input price is shared), whereas in our model bundling forces the firm to choose a single quantity for both markets. Thus, the two markets are linked through quantity in our model, while they are linked through input price in Arya and Mittendorf (2010). Consequently, the welfare mechanisms differ. In Arya and Mittendorf (2010), IPD improves welfare by smoothing output across markets when the competitive market has higher demand. In our model, IPD improves allocative efficiency in the competitive market by reallocating production toward the efficient firm when the bundling firm is inefficient. Our results are driven by the quantity linkage created by bundling and the resulting input price ranking, neither of which is present in Arya and Mittendorf (2010).

We follow the model of pure bundling (Martin, 1999; Hinloopen et al., 2014). Our results suggest that regulators should consider both the identity of the bundling firm and the size of the bundled market when evaluating IPD cases.

2 Model

We consider two products, product A and B. While product A is produced by $D1$ and $D2$, product B is solely produced by $D2$. Hence, $D1$ and $D2$ compete in market A, while $D2$ monopolizes market B. Here, we consider pure bundling where $D2$ bundles one unit of product A with one unit of product B. Following (Martin, 1999; Arya and Mittendorf, 2010), the inverse demand functions in markets A and B are as follows, respectively:

$$p^A = \alpha - q_1 - q_2 \ \text{ and } \ p^B = \beta - q_2,$$

where $\alpha > 0$ and $\beta > 0$ denote the sizes of markets A and B, respectively. Moreover, p^A and p^B denote the prices of products A and B, respectively. q_1 denotes the quantity of $D1$ on product A. Finally, with pure bundling, the quantities of products A and B sold by $D2$ are equal. We denote this bundle quantity as q_2. We focus on the welfare comparison between IPD and UIP when bundling exists. Supposing separate selling requires a fixed cost F (e.g., for separate billing or management), for simplicity, we set

$F = 0$ in our model.[1]

In market A, there exists an upstream firm U. U produces an input at zero marginal cost and sells it to D_i at input price w_i, where $i = 1, 2$. Each downstream firm D_i buys one unit of input from U to produce one unit of product A. We allow for asymmetry in downstream efficiency: in addition to the input price, $D1$ incurs an extra marginal cost of $(1-x)c$, whereas $D2$ incurs an extra marginal cost of xc, where $c \in (0, \min\{\alpha, \beta\})$ and $x \in \{0, 1\}$ is a dummy variable. Thus, D_2 is more inefficient than D_1 when $x = 1$ (Case i), and more efficient when $x = 0$ (Case ii). In market B, by contrast, firm $D2$ sources the input from a perfectly competitive market with zero marginal cost and therefore incurs no input cost. Therefore, the profits of $D1$ and $D2$ (the sum of profits of market A and B) are as follows, respectively.

$$\pi_{D1} = [p^A - w_1 - (1-x)c]q_1, \quad \pi_{D2} = [p^A - w_2 - xc]q_2 + p^B q_2.$$

In market A, U sets input price w_i for D_i. We consider two regimes. Under an input price discrimination (IPD) regime, U may charge differentiated prices (i.e., $w_1 \neq w_2$). Under a uniform input pricing (UIP) regime, it must charge the same input price to both downstream firms (i.e., $w_1 = w_2 = w$). The profit of U is $\pi_U \equiv w_1 q_1 + w_2 q_2$.

Consumer surplus and total surplus are as follows.

$$CS = \frac{q_1^2 + 2q_1 q_2 + 2q_2^2}{2}, \quad TS = CS + \pi_{D1} + \pi_{D2} + \pi_U.$$

We first consider Case (i), and then Case (ii). In Case (i), we assume $\max\{(4\alpha - 15c)/41, c\} < \beta < (12\alpha + 11c)/11$ to guarantee positive equilibrium outcomes. In Case (ii), we assume $c < 6\alpha/17$ and $\max\{(4\alpha + 11c)/41, c\} < \beta < (12\alpha - 23c)/11$ to guarantee positive equilibrium outcomes.[2]

[1] A motivating example is a hotel that bundles breakfast with its rooms. The hotel competes with outside restaurants in the breakfast market (market A), holds a local monopoly over its rooms (market B), and sells rooms only with breakfast included, so one room implies one breakfast (e.g., the Toyoko Inn hotel chain in Japan).

[2] These inequalities ensure that all equilibrium quantities are positive.

The timing of this game is as follows. In stage 1, U chooses input prices according to the pricing regime. In stage 2, downstream firms choose q_i. We solve this game using backward induction.

3 Results

We examine whether IPD harms welfare compared with UIP when bundling exists. Notably, in our model, the upstream supplier serves *only* the competitive market; without bundling, the monopoly market is independent and IPD always reduces total surplus as the well-known result (DeGraba, 1990; Yoshida, 2000).

3.1 Case (i): Inefficient Bundling Firm ($x = 1$)

First, we consider the case where the bundling firm $D2$ is more inefficient than $D1$ in market A (i.e., $x = 1$).

3.1.1 Uniform Input Pricing

In stage 2, from the first-order conditions $\partial \pi_{Di}/\partial q_i = 0$, we obtain the following outputs.

$$q_1(w_1, w_2) = \frac{3\alpha - \beta + c - 4w_1 + w_2}{7}, \quad q_2(w_1, w_2) = \frac{\alpha + 2\beta - 2c + w_1 - 2w_2}{7}.$$

In stage 1, firm U chooses w. Substituting $q_1(w_1, w_2)$ and $q_2(w_1, w_2)$ into π_U and setting $w_1 = w_2 = w$, the first-order condition $\partial \pi_U/\partial w = 0$ yields:

$$w^u = \frac{4\alpha + \beta - c}{8}.$$

From the above, we obtain the consumer and total surpluses under uniform input pricing as follows.

$$CS^u = \frac{272\alpha^2 - 248\alpha c + 241c^2 + (248\alpha - 482c)\beta + 241\beta^2}{6272},$$
$$TS^u = \frac{1520\alpha^2 - 648\alpha c + 1439c^2 + (648\alpha - 2878c)\beta + 1439\beta^2}{6272}.$$

3.1.2 Input Price Discrimination

The stage 2 outcomes are the same as those under UIP. Substituting these outcomes into π_U, the first-order conditions $\partial\pi_U/\partial w_i = 0$ yield:

$$w_1^d = \frac{\alpha}{2}, \quad w_2^d = \frac{\alpha+\beta-c}{2}.$$

Therefore, we obtain the consumer and total surpluses in this case.

$$CS^d = \frac{17\alpha^2 - 12\alpha c + 5c^2 + (12\alpha - 10c)\beta + 5\beta^2}{392},$$
$$TS^d = \frac{95\alpha^2 - 44\alpha c + 51c^2 + (44\alpha - 102c)\beta + 51\beta^2}{392}.$$

3.1.3 Condition for Desirable Input Price Discrimination

We compare the results under UIP and IPD. First, regarding input prices, we obtain the following lemma.

Lemma 1 *When the bundling firm $D2$ is inefficient, the input price ranking is $w_1^d < w^u < w_2^d$.*

The intuition is as follows. Because firm $D2$ engages in bundling, its potential input demand is large. Therefore, under IPD, firm U sets w_2 higher. In contrast, firm $D1$'s potential input demand is small, so firm U sets w_1 lower. Thus, we obtain the ranking in Lemma 1.

Next, we obtain the following proposition on consumer surplus.

Proposition 1 *When the bundling firm $D2$ is inefficient, consumer surplus is always larger under UIP than under IPD.*

The intuition behind Proposition 1 is as follows. As shown in Lemma 1, under IPD, the efficient firm $D1$ faces a lower input price, whereas the inefficient firm $D2$ faces a higher input price. The lower input price increases consumer surplus by inducing firm

$D1$ to expand output. By contrast, the higher input price reduces $D2$'s output and thereby lowers consumer surplus. Moreover, this negative effect extends to market B as well as market A. Therefore, the latter effect dominates the former.

Finally, we obtain the following proposition on total surplus.

Proposition 2 *When the bundling firm $D2$ is inefficient, if the size of market B is sufficiently small, i.e., $\beta < (8\alpha + 89c)/89$, total surplus is larger under IPD than under UIP. Otherwise, total surplus is larger under UIP than under IPD.*

Proof.

$$TS^d - TS^u = \frac{(\beta - c)(8\alpha + 89c - 89\beta)}{896}.$$

Therefore, we have $TS^d > TS^u$ if $\beta < (8\alpha + 89c)/89$. □

The intuition behind Proposition 2 is as follows. As discussed in Proposition 1, under IPD, firm $D2$ reduces production, which decreases total surplus. Moreover, this negative effect becomes more pronounced as the size of market B increases. At the same time, IPD also increases total surplus by improving allocative efficiency through larger production by the more efficient firm, $D1$. Therefore, when the size of market B is small (large), IPD increases (decreases) total surplus.

3.2 Case (ii): Efficient Bundling Firm ($x = 0$)

We now consider the case where the bundling firm $D2$ is more efficient than $D1$ (i.e., $x = 0$). Following the same process as in Subsection 3.1, we obtain the consumer and total surpluses under UIP and IPD as follows.

$$\widetilde{CS}^u = \frac{272\alpha^2 - 296\alpha c + 265c^2 + (248\alpha + 234c)\beta + 241\beta^2}{6272},$$
$$\widetilde{TS}^u = \frac{1520\alpha^2 - 2392\alpha c + 2311c^2 + (648\alpha + 2230c)\beta + 1439\beta^2}{6272},$$
$$\widetilde{CS}^d = \frac{17\alpha^2 - 22\alpha c + 10c^2 + (12\alpha - 2c)\beta + 5\beta^2}{392},$$
$$\widetilde{TS}^d = \frac{95\alpha^2 - 146\alpha c + 102c^2 + (44\alpha + 58c)\beta + 51\beta^2}{392}.$$

Based on the outcomes, we obtain the following proposition.

Proposition 3 *When the bundling firm $D2$ is efficient, both consumer surplus and total surplus are always larger under UIP than under IPD.*

The intuition behind Proposition 3 is as follows. Even in the case where $x = 0$, we obtain the same ranking of input prices as in Lemma 1. In this case, however, this ranking leads to the concentration of production in the inefficient firm, $D1$. Therefore, we obtain the well-known result that both consumer and total surpluses decrease under IPD.

4 Conclusions

This paper examines how bundling affects the welfare consequences of IPD. We find that IPD can enhance welfare when the inefficient firm is the bundling firm and the monopoly market is sufficiently small. When the efficient firm bundles, however, IPD unambiguously reduces both consumer and total surpluses. Our results suggest that regulators should consider both market size and firm identity when evaluating IPD cases involving bundling.

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