Personalized Pricing with Upstream Corporate Social Responsibility and Downstream Investment

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Abstract

This study evaluates personalized pricing in supply chain competition. We consider two supply chains, each comprising an upstream firm with Corporate Social Responsibility (CSR) and a downstream firm investing in quality. A downstream firm's quality investment has two effects: it raises its own consumers' utility and induces the rival downstream firm to lower its price, consequently benefiting the rival's consumers. As personalized pricing is exploitative, the former effect is entirely captured. First, we find that under personalized pricing, a downstream firm's investment benefits only the rival's consumers. In response, the upstream firm with CSR sets a higher input price to expand the rival's market share and increase consumer surplus, which weakens downstream investment incentives and moderates quality competition. Second, we find that personalized pricing may harm consumers while remaining profitable for downstream firms.

JEL codes: D43, L10, L13.

Keywords: personalized pricing, uniform pricing, Corporate Social Responsibility, quality investment, supply chain management

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1 Introduction

Personalized pricing is a system that offers consumers customized prices. In the automotive industry, for example, downstream dealers in supply chains offer prices based on consumers' willingness to pay through negotiations with consumers. Therefore, personalized pricing is prevalent in the automotive industry (Ghose and Huang 2009). This practice has also been observed in other industries such as the supermarket (Matsumura and Matsushima 2015); taxi (Newcomer 2017); and travel agency (Hannak et al. 2014) industries.

As such, personalized pricing has emerged in some industries, subsequently leading policy and regulatory institutions to focus on its effects. In particular, OECD (2018) and Ofcom (2020) have expressed concerns regarding the exploitative nature of personalized pricing, which seems to suggest to us that personalized pricing benefits firms and harms consumers. However, in the personalized pricing literature, it is well known that personalized pricing tends to intensify competition among firms and improve consumer surplus (Choe et al. 2018; Shaffer and Zhang 1995; Thisse and Vives 1988). Therefore, a gap exists between policymakers' and researchers' evaluations of personalized pricing.

Seeking to bridge this gap, several recent studies have challenged the standard claims in the literature (Chen et al. 2020; Esteves 2022; Esteves and Shuai 2022; Laussel and Resende 2022; Liu and Serfes 2013; Lu and Matsushima 2024; Lu and Matsushima 2025; Lu et al. 2025; Matsushima et al. 2023; Rhodes and Zhou 2024). Following this line of research, our study also reexamines whether personalized or uniform pricing is more desirable for consumers and firms.

Personalized pricing is an important issue for firms, and its importance is increasingly recognized in supply chain management. Accordingly, a growing literature examines personalized pricing in supply chains (Du et al. 2022; Jullien et al. 2023; Masuyama 2025). In the supply chain literature, Corporate Social Responsibility (CSR) has also received considerable attention in recent years (Brand and Grothe 2015; Chang et al.

2019; Masuyama and Mizuno 2026; Xue et al. 2024). In particular, when upstream firms engage in CSR and place positive weight on consumer surplus in their objective functions, the input prices they set may deviate from profit-maximizing levels. As input prices directly affect downstream marginal costs and thus downstream price levels, upstream CSR—the objectives of which may diverge from profit maximization—cannot be ignored when analyzing personalized pricing in supply chains.

Accordingly, we consider the following model: Two supply chains compete, each consisting of one upstream firm (manufacturer) and one downstream firm (dealer), and they trade only within their own chains. Each upstream firm engages in CSR, taking consumer surplus in addition to profit into account. In addition, we suppose that each downstream firm can invest in product quality and competes under either personalized or uniform pricing. To compare the two pricing schemes, we assume both downstream firms follow the same exogenously given scheme. Accordingly, we analyze two cases: one in which both firms compete under personalized pricing and another in which both compete under uniform pricing.

Our model corresponds to the automotive industry, which employs personalized pricing. First, the assumption that upstream and downstream firms trade only within their own supply chains reflects *keiretsu*, which is a supply chain system, observed in the Japanese automotive industry, as seen at Toyota. Second, the assumption that upstream firms consider consumer surplus through CSR is consistent with Toyota's declaration in its report that the firm takes consumers into account. In addition, this assumption is standard in the CSR literature (Fanti and Buccellla 2017, 2018; Goering 2007, 2008; Kim et al. 2019; Kopel and Lamantia 2018; Kopel et al. 2014). Finally, as dealer quality is directly linked to consumer satisfaction (Golara et al. 2021), downstream quality investment is an essential element in the automotive industry.[1]

Our main findings are as follows. First, when the degree of upstream CSR is suf-

[1]OECD (2013) notes that, alongside price, quality is a fundamental aspect of competition in markets. This suggests that quality warrants consideration.

ficiently high and downstream quality investment is sufficiently efficient, personalized pricing can harm consumers. Second, under similar conditions, personalized pricing can benefit firms. These findings contrast with the standard results in the personalized pricing literature. The key factor is that, under personalized pricing, upstream CSR reduces downstream quality. Consequently, downstream quality under personalized pricing may be lower than that under uniform pricing, potentially leading to smaller consumer surplus. In addition, by reducing quality competition, personalized pricing may allow downstream firms to earn higher profits.

We discuss the intuition behind why upstream CSR reduces downstream quality under personalized pricing. When a downstream firm invests in quality, two effects on consumers occur. The first is the direct effect: it provides potential additional surplus to the downstream firm's consumers. The second is the indirect effect: the rival firm lowers its price to avoid losing demand due to the quality improvement, thereby benefiting the rival's consumers. Because the direct effect increases the demand for the quality-investing firm, the upstream firm can raise its input price, thereby weakening the downstream firm's incentive to invest. Under uniform pricing, the upstream firm with CSR restrains the input price increase to preserve this investment incentive and to increase the number of its own consumers who benefit from the direct effect. However, this logic breaks down under personalized pricing. Since personalized pricing reflects consumers' willingness to pay, the direct effect disappears, leaving only the indirect effect. The benefits from the quality investment then accrue solely to the rival's consumers. To increase consumer surplus, the CSR-oriented upstream firm raises the input price even further to expand the rival's demand, which in turn reduces the downstream firm's investment incentive.

The mechanism described above is exemplified by the case of Toyota in the Japanese automobile industry. In 2006, Toyota established a department dedicated to CSR. In the same year, Toyota stated in its code of conduct that the firm's objective was to increase consumer satisfaction and promote dealer efficiency in line with this objective.

This can be interpreted as an assertion that if a dealer benefits consumers, Toyota will offer the dealer a better contract, whereas if not, it will refuse to offer favorable terms. Similarly, in our model, an upstream firm with CSR worsens the contract (i.e., offers a higher input price) when downstream personalized pricing harms consumers. Thus, Toyota's behavior is consistent with the underlying mechanism proposed in our study.

This study contributes to the growing literature that evaluates competitive effects of personalized pricing. In this literature, it is well known that personalized pricing tends to intensify competition among firms and benefit consumers (Choe et al. 2018; Shaffer and Zhang 1995; Thisse and Vives 1988). By contrast, several studies, as ours, have challenged this conventional result. Chen et al. (2020) consider a situation in which consumers can avoid personalized pricing through identity management. Esteves (2022) and Matsushima et al. (2023) focus on heterogeneous consumer types, while Esteves and Shuai (2022) focus on elastic demands. Laussel and Resende (2022) consider a two-period model and demonstrate the profitability of product-price personalization. Liu and Serfes (2013) and Lu et al. (2025) consider two-sided markets. Lu and Matsushima (2024, 2025) consider the case where consumers can choose multiple firms. Rhodes and Zhou (2024) analyze a generalized oligopoly model based on Perloff and Salop (1985). Note that, unlike our study, these studies do not focus on the case where marginal costs are endogenously determined.

Some studies have examined endogenously determined marginal costs under personalized pricing, as in our study. Matsumura and Matsushima (2015) do not consider upstream markets, but they do consider marginal cost reduction investments by firms that implement personalized pricing. They find that personalized pricing benefits consumers, which contrasts with our results. Similar to our approach, other studies have incorporated upstream markets. Du et al. (2022) consider a vertical market with a monopolistic upstream firm and two downstream firms with asymmetric abilities to implement personalized pricing. They emphasize the pro-competitive effects of personalized pricing, thus

reaching different conclusions from ours. Jullien et al. (2023) analyze a model in which a monopolistic upstream firm operates through two distribution channels: a direct channel and a channel through a downstream firm. They reveal that personalized pricing can amount to exploitative pricing that extracts consumer surplus if the upstream firm sets an appropriate input price. Masuyama (2025) considers supply chain competition, as we do, but concludes that personalized pricing increases consumer surplus, again reaching a different conclusion from ours. Neither of these studies focuses on CSR and quality investment in vertical relationships. Therefore, the mechanism underlying our results does not derive from these prior works.

This study also contributes to the recent CSR literature (Bian et al. 2016; Buccella et al. 2024; Fanti and Buccella 2017, 2018; Matsumura and Ogawa 2014; Kim et al. 2019; Kopel and Brand 2012; Kopel and Lamantia 2018; Kopel et al. 2014; Planer-Friedrich and Sahm 2020). Several studies examine upstream CSR (Brand and Grothe 2015; Masuyama and Mizuno 2026; Xue et al. 2024) and show that it mitigates the double marginalization problem. By contrast, we find that upstream CSR can reduce welfare once personalized pricing is considered, which is an aspect that is not addressed in the literature. This occurs because upstream CSR lowers downstream quality under personalized pricing.

The remainder of this paper is organized as follows. The next section explains the model. Section 3 calculates the equilibrium and provides the results. Finally, Section 4 presents our conclusions.

2 Model

We consider two supply chains, supply chains i $(= A, B)$, competing for consumers uniformly distributed in a linear market along the interval $[0, 1]$. Each supply chain's location is exogenous: supply chain A is located at 0 and supply chain B is located at 1. In addition, supply chain i has one upstream firm, firm Ui, and one downstream firm,

firm Di, which exclusively trade.

Each downstream firm sells the final good with either personalized or uniform pricing. Under personalized pricing, each downstream firm offers a customized price to the consumer located at x on the interval $[0, 1]$. Under uniform pricing, each downstream firm offers the same price to all consumers. In addition, the pricing scheme of the downstream firms is exogenous, and we focus on the cases where both downstream firms employ personalized pricing and where both employ uniform pricing. Furthermore, each downstream firm invests in its quality.

Consumers purchase at most one unit of the final good from either supply chain A or B. We define the utility of consumer x, the consumer located at x, as follows.

$$U(p_i(x), i, x) = \begin{cases} v + \phi_A - p_A(x) - tx & \text{if the consumer chooses supply chain } A, \\ v + \phi_B - p_B(x) - t(1-x) & \text{if the consumer chooses supply chain } B. \end{cases}$$

$v(> 0)$ is the utility from consumption, which is sufficiently large that all consumers purchase the goods. $t(> 0)$ is the transportation cost parameter. ϕ_i is the quality level of firm Di. $p_i(x)$ is the final good price offered by firm Di to consumer x. Under personalized pricing, this price depends on x, but it is independent of x under uniform pricing. We denote this uniform price by p_i. Based on the above, the consumer surplus is defined as follows:

$$CS = \int_0^{\hat{x}} [v + \phi_A - p_A(x) - tx]\, dx + \int_{\hat{x}}^1 [v + \phi_B - p_B(x) - t(1-x)]\, dx,$$

where $\hat{x}$ denotes the location of the consumer who is indifferent between buying from supply chains A and B.

Firm Ui produces its input at zero marginal cost and sells it to firm Di at the input price w_i. Accordingly, we define the profit of firm Ui as follows:

$$\pi_{U_A} = w_A \hat{x}, \quad \pi_{U_B} = w_B(1 - \hat{x}).$$

In addition, firm Ui considers the consumer surplus in committing to CSR. Following the literature on CSR (Bian et al. 2016; Fanti and Buccellla 2018; Kim et al. 2019;

Kopel and Brand 2012; Kopel and Lamantia 2018; Kopel et al. 2014; Planer-Friedrich and Sahm 2020), we denote the objective function of firm Ui with CSR as follows.

$$V_{Ui} = (1-\theta)\pi_{Ui} + \theta CS.$$

To guarantee positive upstream firms' profits, we assume $\theta \in [0, 1/2)$.

Firm Di incurs only marginal cost w_i, which is the input price paid to firm Ui. We also assume that choosing the quality level ϕ_i requires the cost $k\phi_i^2/2$. The profit of each downstream firm is expressed as follows.

$$\pi_{D_A} = \int_0^{\hat{x}} [p_A(x) - w_A]\, dx - k\frac{\phi_A^2}{2}, \quad \pi_{D_B} = \int_{\hat{x}}^1 [p_B(x) - w_B]\, dx - k\frac{\phi_B^2}{2}.$$

Here, k denotes the inefficiency of downstream quality investment. In other words, the smaller k, the more efficient the quality investment. To ensure the concavity of downstream firms' profits, we assume $k > \underline{k} = \max\{k_1, k_2\}$, where $k_1 = (1-\theta)^2/[2t(3-\theta)^2]$, $k_2 = (1-\theta)^2/[t(9-11\theta)^2]$.[2]

The timing is as follows. In stage 1, firm Di decides its quality level ϕ_i. In stage 2, firm Ui chooses its input price w_i to maximize the objective function V_{Ui}. The stage structure where investment in quality is prior to the input pricing reflects the fact that the adjustment of input price is more flexible than the decision to invest in quality, and this stage structure is a standard assumption in the context of investment. In stage 3, firm Di competes under a given pricing scheme, personalized or uniform pricing. Using backward induction, we solve this game.

3 Results

3.1 Both downstream firms compete under uniform pricing.

In this subsection, we consider the case in which both downstream firms use uniform pricing. We denote this case by the superscript UU.

[2]First, under personalized pricing, the downstream firms' profits are concave when $k > k_1$. Second, under uniform pricing, the downstream firms' profits are concave when $k > k_2$. Finally, for $[0, (93 - 24\sqrt{2})/119]$, $k_1 > k_2$, and $k_2 > k_1$ otherwise.

In stage 3, we obtain the location of the indifferent consumers as follows.

$$\hat{x}^{UU} = \frac{t + \phi_A - \phi_B - p_A + p_B}{2t}.$$

From the first-order condition on p_i, we obtain the following outcome.

$$p_i = \frac{3t + \phi_i - \phi_j + 2w_i + w_j}{3}.$$

In stage 2, each upstream firm chooses its input price to maximize the objective function. The first-order condition on w_i leads to the following outcome.

$$w_i^{UU} = \frac{3(9 - 29\theta + 22\theta^2)t + (3 - 7\theta + 4\theta^2)\phi_i - (3 - 7\theta + 4\theta^2)\phi_j}{9 - 20\theta + 11\theta^2}.$$

Now, we obtain the results summarized in Lemma 1 for the downstream quality ϕ_i, the degree of upstream CSR θ, and the input price w_i.

Lemma 1 *We consider the case where both downstream firms utilize uniform pricing. (i) The input price increases with downstream quality. (ii) The effect of downstream quality on the input price decreases with the degree of upstream CSR.*

Proof.

$$\frac{\partial w_i^{UU}}{\partial \phi_i} = \frac{3 - 4\theta}{9 - 11\theta} > 0, \quad \frac{\partial^2 w_i^{UU}}{\partial \theta \partial \phi_i} = -\frac{3}{(9 - 11\theta)^2} < 0. \quad \square$$

An intuition behind Lemma 1 (i) is as follows. Improving downstream quality ϕ_i increases the demand of supply chain i. Therefore, firm Ui raises its input price w_i. However, if the degree of upstream CSR θ is high, firm Ui limits the rise in its input price w_i to force firm Di to improve the consumer surplus. This is an intuition behind Lemma 1 (ii).

In stage 1, the first-order condition on ϕ_i leads to the following outcome.

$$\phi_i^{UU} = \frac{1 - \theta}{k(9 - 11\theta)}.$$

Now, differentiating ϕ_i^{UU} with respect to θ, we obtain Lemma 2.

Lemma 2 *We consider the case where both downstream firms utilize uniform pricing. Downstream quality increases with the degree of upstream CSR.*

Proof.

$$\frac{\partial \phi_i^{UU}}{\partial \theta} = \frac{2}{k(9-11\theta)^2} > 0.$$

An intuition behind Lemma 2 is as follows. If the degree of upstream CSR is high, each upstream firm attempts to keep the input price as low as possible, from Lemma 1. This means that each downstream firm has an incentive to improve its quality.

Finally, by using the outcomes obtained above, we have the profits, consumer surplus, and total surplus as follows.

$$\pi_{Di}^{UU} = \frac{kt(9-11\theta)^2 - (1-\theta)^2}{2k(9-11\theta)^2}, \quad \pi_{Ui}^{UU} = \frac{3t(1-2\theta)}{2(1-\theta)},$$
$$CS^{UU} = v - \frac{(319kt-4)\theta^2 - (448kt-8)\theta + 153kt - 4}{4k(1-\theta)(9-11\theta)},$$
$$TS^{UU} = v - \frac{(121kt-40)\theta^2 - (198kt-72)\theta + 81kt - 32}{4k(9-11\theta)^2}.$$

The comparative statics for consumer surplus are summarized in Proposition 1.

Proposition 1 *We consider the case where both downstream firms utilize uniform pricing. Consumer surplus increases with the degree of upstream CSR.*

Proof.

$$\frac{\partial CS^{UU}}{\partial \theta} = \frac{3kt(9-11\theta)^2 + 2(1-\theta)^2}{k(9-11\theta)^2(1-\theta)^2} > 0. \quad \square$$

An intuition behind Proposition 1 is as follows. As we demonstrated in Lemma 2, higher upstream CSR improves downstream quality. Therefore, consumers can purchase goods with higher quality and thus the consumer surplus improves.

3.2 Both downstream firms compete under personalized pricing.

In this subsection, we consider the case in which both downstream firms use personalized pricing. We denote this case by the superscript PP.

In stage 3, the minimum price of each downstream firm is its input price. Therefore, firm DA offers the following prices to consumer x.

$$p_A(x) = \begin{cases} \phi_A - \phi_B + w_B + t(1-2x) & \text{if } w_A < \phi_A - \phi_B + w_B + t(1-2x), \\ w_A & \text{otherwise.} \end{cases}$$

Firm DB sets the prices as follows.

$$p_B(x) = \begin{cases} \phi_B - \phi_A + w_A + t(2x-1) & \text{if } w_B < \phi_B - \phi_A + w_A + t(2x-1), \\ w_B & \text{otherwise.} \end{cases}$$

Accordingly, we obtain the indifferent consumer as follows.

$$\hat{x}^{PP} = \frac{t + \phi_A - \phi_B - w_A + w_B}{2}.$$

Furthermore, we analyze the surplus that each supply chain's own consumers receive through these personalized prices. We call the consumers purchasing from supply chain i "consumer group i." The utility $u_A(p_A(x), A, x)$ of consumers in consumer group A is as follows.

$$u_A(p_A(x), A, x) = v + \phi_B - w_B - t(1-x).$$

The utility $u_B(p_B(x), B, x)$ of consumers in consumer group B is as follows.

$$u_B(p_B(x), B, x) = v + \phi_A - w_A - tx.$$

Therefore, we obtain the result in Lemma 3 regarding the surplus of each consumer group under personalized pricing.

Lemma 3 *We consider the case where both downstream firms utilize personalized pricing. When firm Di increases quality, consumer group i does not benefit from the quality increase; instead, consumer group j does.*

An intuition behind Lemma 3 is as follows. An improvement in downstream quality ϕ_i leads directly to an increase in the personalized price $p_i(x)$. Therefore, even if a consumer's willingness to pay increases due to an increase in ϕ_i, it is all absorbed by

the personalized price. Thus, consumer group i receives no benefit. By contrast, if the quality ϕ_i improves, firm Dj responds by lowering its price to avoid losing market share. Therefore, consumer group j receives the benefit of the improvement in ϕ_i through the lower price.

In stage 2, each upstream firm chooses its input price to maximize the objective function. The first-order condition on w_i yields the following outcome.

$$w_i^{PP} = \frac{t(3 - 7\theta + 2\theta^2) + (1 - \theta)\phi_i - (1 - \theta)\phi_j}{3 - 4\theta + \theta^2}.$$

We obtain Lemma 4 for the downstream quality ϕ_i, the degree of upstream CSR θ, and the input price w_i.

Lemma 4 *We consider the case where both downstream firms utilize personalized pricing. (i) The input price increases with downstream quality. (ii) The effect of downstream quality on the input price increases with the degree of upstream CSR.*

Proof.

$$\frac{\partial w_i^{PP}}{\partial \phi_i} = \frac{1}{3 - \theta} > 0, \quad \frac{\partial^2 w_i^{PP}}{\partial \theta \partial \phi_i} = \frac{1}{(3 - \theta)^2} > 0. \quad \square$$

An intuition behind Lemma 4 (i) is similar to that of Lemma 1 (i). As downstream quality ϕ_i improves, the demand in supply chain i increases. Therefore, firm Ui raises input price w_i. Lemma 4 (ii) argues that the extent of the input price rise is larger with upstream CSR θ. From Lemma 3, the improvement in downstream quality ϕ_i only benefits consumer group j. Therefore, firm Ui considering consumer surplus reduces its own demand and gives a larger demand to its rival. To achieve this goal, firm Ui with CSR raises input price w_i even more.

In stage 1, from the first-order condition on ϕ_i, we obtain the following outcome:

$$\phi_i^{PP} = \frac{1 - \theta}{2k(3 - \theta)}.$$

Here, differentiating ϕ_i^{PP} with θ, we obtain Lemma 5.

Lemma 5 *We consider the case where both downstream firms utilize personalized pricing. Downstream quality decreases with the degree of upstream CSR.*

Proof.

$$\frac{\partial \phi_i^{PP}}{\partial \theta} = -\frac{1}{k(3-\theta)^2} < 0. \quad \square$$

An intuition behind Lemma 5 is as follows. From Lemma 4 (ii), when upstream CSR progresses, the rise in input price due to downstream quality improvement becomes larger. Thus, upstream CSR weakens the incentive for each downstream firm to improve quality.

Finally, from the outcomes obtained above, we obtain the profits, consumer surplus, and total surplus as follows.

$$\pi_{Di}^{PP} = \frac{2kt(3-\theta)^2 - (1-\theta)^2}{8k(3-\theta)^2}, \quad \pi_{Ui}^{PP} = \frac{t(1-2\theta)}{2(1-\theta)},$$
$$CS^{PP} = v - \frac{(11kt-2)\theta^2 - (40kt-4)\theta + 21kt - 2}{4k(3-\theta)(1-\theta)},$$
$$TS^{PP} = v - \frac{(kt-1)\theta^2 - (6kt-6)\theta + 9kt - 5}{4k(3-\theta)^2}.$$

We obtain the comparative statics for consumer surplus, as summarized in Proposition 2.

Proposition 2 *We consider the case in which both downstream firms utilize personalized pricing. When downstream quality investment is sufficiently efficient,* $\underline{k} < k < (1-\theta)^2/[t(3-\theta)^2]$*, consumer surplus decreases with the degree of upstream CSR; otherwise, it increases with the degree of upstream CSR.*

Proof. See Appendix.

An intuition behind Proposition 2 is as follows. A higher degree of upstream CSR has two effects on consumer surplus. First, upstream CSR mitigates the double marginalization problem, as is well known in the CSR literature. Second, upstream CSR reduces downstream quality, as shown in Lemma 5. When downstream quality investment is

sufficiently efficient, such quality tends to be high, thereby enhancing the latter effect. Therefore, when downstream quality investment is sufficiently efficient, upstream CSR reduces consumer surplus.

Proposition 2 suggests that we should carefully examine the effects of CSR known in the context of it. In general, CSR is desirable for consumers. However, we show that CSR may be harmful to consumers under personalized pricing. Therefore, whether to require firms to be socially responsible depends on downstream pricing and the efficiency of quality investment.

3.3 Comparison: uniform pricing vs. personalized pricing.

In this subsection, we compare the consumer surplus, profit of each firm, and total surplus under uniform and personalized pricing. As a first step, we compare downstream quality under each pricing. The results obtained in Lemmas 2 and 5 are illustrated in Figure 1. The horizontal and vertical axes are the degree of upstream CSR θ and downstream quality ϕ_i, respectively. Applying $k = 1$, we draw downstream quality under each pricing. The dotted and solid curves represent downstream quality under uniform and personalized pricing, respectively.

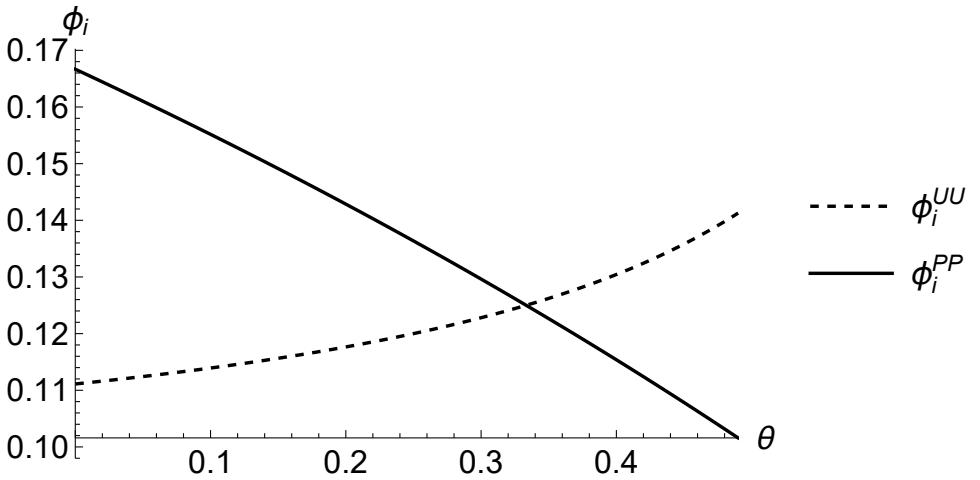

Figure 1: Downstream quality under uniform and personalized pricing.

Under uniform pricing, upstream CSR improves downstream quality, whereas under personalized pricing, upstream CSR worsens such quality. Therefore, with a sufficiently high degree of upstream CSR, downstream quality under uniform pricing is higher than that under personalized pricing. This discussion is summarized in Proposition 3.

Proposition 3 *When the degree of upstream CSR is high, $1/3 < \theta < 1/2$, downstream quality is higher under uniform pricing than under personalized pricing; otherwise, it is higher under personalized pricing.*

Proof.

$$\phi_i^{UU} - \phi_i^{PP} = \frac{3(1-\theta)(-1+3\theta)}{2k(3-\theta)(9-11\theta)} > 0 \ \text{ if } \ \theta > \frac{1}{3}. \ \square$$

Here, comparing the consumer surplus under uniform and personalized pricing yields Proposition 4.

Proposition 4 *When the degree of upstream CSR is sufficiently high and downstream quality investment is sufficiently efficient, $(98 - \sqrt{2233})/117 < \theta < 1/2$ and $\underline{k} < k < k_{CS} = 3(1-\theta)^2(-1+3\theta)/[t(3-\theta)(5-9\theta)(9-11\theta)]$, consumer surplus is higher under uniform pricing than under personalized pricing; otherwise, it is higher under personalized pricing.*

Proof. See Appendix.

Proposition 4 is visually illustrated in Figure 2. The horizontal and vertical axes represent the degree of downstream CSR θ and the inefficiency of downstream quality investment k, respectively. The figure focuses on the domain $\theta \in [0, 1/2)$ and $k \in [0, 1/10]$, with $t = 1$ assumed throughout. The solid and dotted curves correspond to $\underline{k}$ and k_{CS}, respectively. We do not consider the region below the solid curve, as it does not guarantee that the profit of each downstream firm is concave. Therefore, we focus on the region above the solid curve. In the blue area below the dotted curve, consumer surplus is higher under uniform pricing than under personalized pricing. Conversely, in

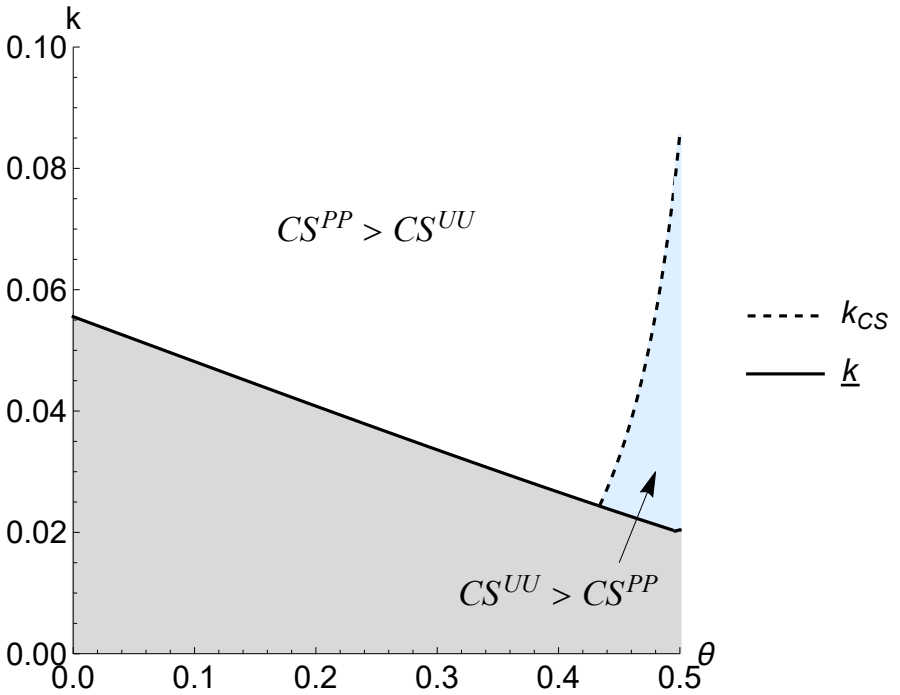

Figure 2: Pricing scheme leading to higher consumer surplus: personalized or uniform pricing.

the area above the dotted curve, consumer surplus is higher under personalized pricing than under uniform pricing.

An intuition behind Proposition 4 is as follows. As shown in Proposition 3, when the degree of upstream CSR is sufficiently high, downstream quality under uniform pricing is higher than that under personalized pricing. In addition, the quality difference is larger if downstream quality investment is more efficient. Therefore, when the degree of upstream CSR is sufficiently high and downstream quality investment is sufficiently efficient, consumer surplus under uniform pricing is higher than that under personalized pricing.

In Figure 2, the blue area, where uniform pricing leads to higher consumer surplus, lies to the right of the threshold $\theta = 1/3$ identified in Proposition 3. Let us now consider the intuition behind this. Personalized pricing is more competitive, and thus tends to result in higher consumer surplus. By contrast, when the degree of upstream CSR is

high, downstream quality under uniform pricing becomes higher, as shown in Proposition 3. However, the quality difference remains small unless the degree of upstream CSR is sufficiently large. Therefore, for the latter effect to dominate the former effect, we require a higher degree of upstream CSR.

Proposition 5 follows from comparisons of the firms' profits under each pricing scheme.

Proposition 5 *(i) The profit of each upstream firm is always higher under uniform pricing than under personalized pricing. (ii) When the degree of upstream CSR is sufficiently high and downstream quality investment is sufficiently efficient,* $(93 - 24\sqrt{2})/119 < \theta < 1/2$ *and* $\underline{k} < k < k_D = [3(1-\theta)^2(-15+58\theta-39\theta^2)]/[2t(27-42\theta+11\theta^2)^2]$*, the profit of each downstream firm is higher under personalized pricing than under uniform pricing; otherwise, it is higher under uniform pricing.*

Proof. See Appendix.

An intuition behind Proposition 5 is as follows. First, we consider Proposition 5 (i). When downstream firms use personalized pricing, price competition is more intense than under uniform pricing. Intense competition among downstream firms forces upstream firms to lower their input prices, thereby reducing their profits. Next, we consider Proposition 5 (ii). As discussed in Propositions 3 and 4, when the degree of upstream CSR is sufficiently high, downstream quality is higher under uniform pricing than under personalized pricing, and the difference becomes larger as downstream quality investment becomes more efficient. In other words, downstream quality competition is less intense under personalized pricing in this case. Therefore, personalized pricing yields higher downstream profits; otherwise, we obtain the standard result that uniform pricing yields higher downstream profits.

Proposition 6 *When the degree of upstream CSR is high,* $1/3 < \theta < 1/2$*, total surplus is higher under uniform pricing than under personalized pricing; otherwise, it is higher under personalized pricing.*

Proof.

$$TS^{UU} - TS^{PP} = \frac{3(1-\theta)(39-56\theta+9\theta^2)(-1+3\theta)}{4k(3-\theta)^2(9-11\theta)^2} > 0 \text{ if } \theta > \frac{1}{3}. \quad \square$$

An intuition behind Proposition 6 is as follows. When the market is fully covered, price does not affect total surplus, and only quality affects it. As shown in Proposition 3, when the degree of upstream CSR is high, quality under uniform pricing is higher than under personalized pricing. Therefore, in this case, uniform pricing leads to higher total surplus.

4 Conclusion

We would expect that uniform pricing is more desirable to consumers than personalized pricing; however, in the literature, personalized pricing is known to be preferable. This study fills this gap by considering upstream firms committed to CSR and downstream firms invested in quality. In particular, uniform pricing is more desirable for consumers under the following conditions: when the degree of upstream CSR is sufficiently high and downstream quality investment is sufficiently efficient. Otherwise, personalized pricing is more desirable for consumers.

In addition, we analyze whether personalized or uniform pricing is preferable for firms in supply chains. First, uniform pricing is preferable for upstream firms, as moderate downstream competition allows them to increase their margins. Second, personalized pricing mitigates quality competition and is therefore preferable for downstream firms when the degree of upstream CSR is sufficiently high and downstream quality investment is sufficiently efficient. This contrasts with conventional wisdom: typically, personalized pricing simply intensifies competition, thus making uniform pricing more desirable for profits. Thus, our study provides managerial insights into pricing strategies by identifying the conditions under which personalized pricing becomes preferable for downstream firms.

Our study assumes that the indicator of CSR is consumer surplus, which is the most common approach in the CSR literature. Adopted in several studies (Hino and Zennyo 2017; Matsumura and Ogawa 2014), an alternative approach is to use total surplus instead. Examining how our main results change under this alternative assumption would be worthwhile. We leave this for future research.

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Appendix

A.1 Proof of Proposition 2.

Differentiating CS^{PP} with respect to θ, we obtain the following result:

$$\frac{\partial CS^{PP}}{\partial \theta} = \frac{-(1-\theta)^2 + kt(3-\theta)^2}{k(1-\theta)^2(3-\theta)^2}.$$

Thus, we have $\partial CS^{PP}/\partial\theta < 0$ if $k < (1-\theta)^2/[t(3-\theta)^2]$. Now, for any θ, $(1-\theta)^2/[t(3-\theta)^2] > \underline{k}$. Therefore, we obtain Proposition 2.□

A.2 Proof of Proposition 3.

Calculating $CS^{UU} - CS^{PP}$ yields the following result:

$$CS^{UU} - CS^{PP} = \frac{3(1-\theta)^2(-1+3\theta) - kt(135 - 453\theta + 433\theta^2 - 99\theta^3)}{2k(1-\theta)(3-\theta)(9-11\theta)}.$$

Therefore, if $k < k_{CS} = 3(1-\theta)^2(-1+3\theta)/[t(3-\theta)(5-9\theta)(9-11\theta)]$, we obtain $CS^{UU} - CS^{PP} > 0$. Here, $k_{CS} > \underline{k}$ requires $(98 - \sqrt{2233})/117 < \theta < 1/2$. From the above, we obtain Proposition 3.□

A.3 Proof of Proposition 4.

First, we consider Proposition 4 (i). Calculating $\pi_{Ui}^{UU} - \pi_{Ui}^{PP}$, we obtain the following result:

$$\pi_{Ui}^{UU} - \pi_{Ui}^{PP} = \frac{t(1-2\theta)}{1-\theta} > 0.$$

Second, we consider Proposition 4 (ii). Calculating $\pi_{Di}^{UU} - \pi_{Di}^{PP}$ yields the following result:

$$\pi_{Di}^{UU} - \pi_{Di}^{PP} = \frac{3(1-\theta)^2(15 - 58\theta + 39\theta^2) + 2kt(27 - 42\theta + 11\theta^2)^2}{8k(3-\theta)^2(9-11\theta)^2}.$$

Therefore, we have $\pi_{Di}^{UU} - \pi_{Di}^{PP} \geq 0$ if $k \geq k_D = [3(1-\theta)^2(-15 + 58\theta - 39\theta^2)]/[2t(27 - 42\theta + 11\theta^2)^2]$. Namely, we obtain $\pi_{Di}^{PP} - \pi_{Di}^{UU} > 0$ if $k < k_D$. Here, $k_D > \underline{k}$ requires $(93 - 24\sqrt{2})/119 < \theta < 1/2$. From the above, we obtain Proposition 4.□