Discussion Paper Series
RIEB
Kobe University

DP2025-13

Targeted Pricing and Vertical Structure*

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June 4, 2025

* This Discussion Paper won the Kanematsu Prize (FY 2024).

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Abstract

Targeted pricing is an aggressive strategy to steal demand from rivals. Therefore, it is believed that firms should employ it. However, targeted pricing has rarely been observed. There is a gap between our perceptions in the literature on targeted pricing and reality. This study demonstrates the negative aspects of targeted pricing by considering supply chain competition. When a rival supply chain is vertically separated, targeted pricing lowers the rival's input price and intensifies competition. Conversely, when the rival firm is vertically integrated, this effect does not occur. Therefore, a firm should confirm its rival's vertical structure when deciding whether to employ targeted pricing.

JEL codes: D43, L10, L13.

Keywords: targeted pricing, uniform pricing, vertical structure, supply chain management, Hotelling model.

*This study was honored with the Kanematsu Prize from the Research Institute for Economics and Business Administration (RIEB) at Kobe University in 2024. I am grateful to anonymous reviewers of the Kanematsu Prize for their constructive comments. I also acknowledge Masahiro Ashiya, Noriaki Matsushima, Eiichi Miyagawa, Tomomichi Mizuno, and Ken-Ichi Shimomura for their comments, which have greatly improved the quality of this paper. This study was supported by JST SPRING, Grant Number JPMJSP2148. The usual disclaimer applies.

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1 Introduction

Recently, firms have gained the ability to offer targeted prices to consumers. In the U.K. supermarket industry, Tesco introduced targeted pricing named “Clubcard Prices” to loyalty card holders in 2019, and Sainsbury’s followed suit with “My Nectar Prices” in 2021. Meanwhile, in the soft drink industry, the pricing scheme is uniform pricing. Although Coca-Cola considered to adjust prices according to consumer demand in 1999, it has not adopted such pricing to date (Seele et al. 2021). Many researchers have analyzed why some industries use targeted pricing while others use uniform pricing (Bester and Petrakis 1996; Ghose and Huang 2009; Matsumura and Mastushima 2015; Shaffer and Zhang 1995; Thisse and Vives 1988).

Targeted pricing is a more aggressive pricing scheme that competes for each consumer, which allows firms to gain a larger market share. Therefore, it has been widely believed that firms do not abandon their ability to engage in target pricing. This study applies this argument to supply chain competition. Since downstream firms purchase inputs from upstream firms in the supply chains, it is necessary to consider the impact of adopting a certain pricing scheme in the downstream market on input prices. Switching from targeted pricing to uniform pricing reduces own demand and hence increases the demand of the rival supply chain. Then, if the rival upstream firm is not integrated with the downstream firm, it chooses a higher input price facing larger input demand, which eases competition in the downstream market. Thus, switching to uniform pricing increases profit if this input-price effect dominates the demand-reduction effect. Notably, this input-price effect disappears when the rival supply chain is vertically integrated.

To capture the effects of input price, we consider the following model. Two supply chains compete for consumers uniformly distributed in a linear market. Each supply chain has an upstream firm and a downstream firm, which trade exclusively under a wholesale contract. In the main model, the vertical structure of each supply chain is treated exogenously, and we consider the following cases: both are vertically integrated, both are vertically separated, and only one is vertically integrated (subsection 4.3 analyzes the endogenous choice of the vertical structure). First, each downstream firm decides whether to adopt targeted or uniform pricing. Next, the upstream firms choose their input prices to maximize their own profits. If the upstream firm is vertically integrated, it employs the marginal cost pricing. Finally, each downstream firm competes under the established pricing schemes.

Our main findings are as follows. Whether a firm uses targeted or uniform pricing does not depend on the vertical structure of its own supply chain. It depends only on the vertical structure of its rival. Uniform pricing is optimal if the rival supply chain is vertically separated, whereas targeted pricing is optimal if it is vertically integrated. These insights align with the actual pricing schemes observed in reality. For example, the soft drink industry, where uniform pricing prevails, is often interpreted as a market with vertically separated supply chains (McGuire and Staelin 1983). Contrastingly, Tesco and Sainsbury's, the U.K. supermarket giants, can beat down the purchase price. Hence they can be interpreted as vertically integrated supply chains (Choe et al. 2018; Matsumuta and Matsushima 2015). These two firms employ targeted pricing through customer loyalty programs.

Our results suggest that a firm determines its pricing scheme based only on its rival's vertical structure. When the rival is vertically separated, it chooses uniform pricing, even if it has sufficient consumer data to employ targeted pricing. Therefore, relaxing regulations such as the EU General Data Protection Regulation (GDPR), that is, allowing access to consumer data, may not necessarily promote competition, contrary to the assertion of Vestager (2019).[1] This is a cautionary tale for regulating authorities.

This study is closely related to a growing stream of literature investigating targeted and uniform pricing. Most studies analyze simple market structures without considering vertical structures. Bester and Petrakis (1996), Matsushima et al. (2023), Shaffer and Zhang (1995), and Thisse and Vives (1988), among others, show that firms choose targeted pricing over

[1] Margrethe Vestager, the head of the EU competition authority, stated, "[A]s data becomes increasingly important for competition, it may not be long before the Commission has to tackle cases where giving access to data is the best way to restore competition."

uniform pricing. However, several studies which consider non-price variables show that firms may adopt uniform pricing (Choudary et al. 2005; Li et al. 2023; Matsumura and Matsushima 2015; Foros et al. 2024).[2]

Some studies consider vertical structures. Du et al. (2022) consider a market with a monopolistic upstream firm and two downstream firms (a dominant firm and a fringe firm). They assume that only the dominant firm can practice targeted pricing and show that it reduces its profit. This is because targeted pricing reduces the fringe firm's input price, thereby intensifying competition. Thus, this mechanism is similar to our intuition. While Du et al. (2022) focus on a fixed vertical structure with a common upstream firm, we analyze the impact of various vertical structures of competing supply chains on the pricing scheme decisions.

Jullien et al. (2023) and Liu and Zhang (2006) analyze models where a monopolistic upstream firm has two channels: a traditional channel through an independent downstream firm and a direct channel without it. Jullien et al. (2023) show that uniform pricing is desirable for the upstream firm because it reduces direct competition in the downstream market. Liu and Zhang (2006) show that the downstream firm should adopt targeted pricing to prevent the upstream firm from using the direct channel. Therefore, our intuition differs from that of these two studies.

Our subsection 4.3 contributes to the literature on endogenous vertical structure. McGuire and Staelin (1983) show that vertical separation is realized in equilibrium when goods are close substitutes. Coughlan (1985) generalizes the model of McGuire and Staelin (1983) and confirms its robustness. Moorthy (1988) focuses on the strategic interaction between firms and generalizes their results. Many other studies support the results of McGuire and Staelin (1983) through some factors: economies of scale (Atkins and Liang 2010), degree of spillover (Gupta 2008), efficiency of cost reduction (Gupta and Loulou 1998), and endogenous product positioning (Liu and Tyagi 2011). They all show that vertical separation mitigates direct

[2]Ghose and Hoang (2009) and Shaffer and Zhang (2002) show that uniform pricing is adopted when targeted pricing involves large enough costs.

competition among upstream firms and hence vertical separation is realized in equilibrium. Our study complements this intuition by explicitly considering pricing scheme decisions.

The remainder of this study is organized as follows. The next section explains the model. Section 3 calculates the equilibrium and provides the results. Section 4 extends the model in several directions. Finally, Section 5 presents the conclusion.

2 Model

We consider two supply chains, supply chain i $(= A, B)$, competing for consumers uniformly distributed in an interval $[0, 1]$. Supply chains A is located at 0, and B is located at 1. We assume that supply chain i has one upstream firm (firm Ui) and one downstream firm (firm Di) and that they trade exclusively within the supply chain. In each supply chain, the upstream and downstream firms may be vertically integrated or vertically separated. The vertical structure is assumed to be exogenous. If Di and Ui are vertically integrated, we refer to this firm as Vi. In subsection 4.3, we relax this assumption and consider a model where the vertical structure is chosen endogenously.

Firm Di (or firm Vi when Di and Ui are integrated) chooses one of the following pricing schemes: uniform pricing (UP) or targeted pricing (TP). Under uniform pricing, firm Di (or firm Vi) offers the same price to all consumers. Under targeted pricing, it offers the targeted price to the consumer at x on the interval $[0, 1]$. We refer to the consumer at x as consumer x.

The consumer purchases at most one unit of the good from either supply chain A or supply chain B. The utility function for consumer x is as follows.

$$V(x) = \begin{cases} v - p_A(x) - tx & \text{if the consumer purchases from supply chain } A, \\ v - p_B(x) - t(1-x) & \text{if the consumer purchases from supply chain } B. \end{cases}$$

Here, v (> 0) is the gross utility for the ideal good and t (> 0) is the transportation cost parameter. We assume that v is large enough that all consumers buy the goods. $p_i(x)$ is the price at which consumer x purchases the good in supply chain i; under targeted pricing, this price depends on x. Under uniform pricing, this price is independent of x and constant, and we denote this uniform price by p_i.

Upstream firm Ui produces the input without costs and sells it to downstream firm Di at input price w_i. Each downstream firm requires one unit of the input to produce one unit of the final good. We define the profit of each upstream firm as follows:

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

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

The downstream firms simultaneously decide whether to sell the final goods to consumers through targeted or uniform pricing. If a supply chain is vertically integrated, the vertically integrated firm makes this decision. We assume that each downstream firm incurs no costs other than the input price it pays to its upstream firm. We define the profit of each downstream firm as follows:

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

If supply chain i is vertically integrated, we define the payoff for the vertically integrated firm as $\pi_{Vi} = \pi_{Di} + \pi_{Ui}$.

Finally, consumer surplus is defined as follows:

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

The timing of the game is as follows. In stage 1, the downstream firms (or the vertically integrated firms) simultaneously choose whether to adopt TP or UP. Thus, the set of strategies of firm Di (or Vi) is $\{TP, UP\}$. When firm DA (or VA) employs $s_A \in \{TP, UP\}$ and firm DB (or VB) employs $s_B \in \{TP, UP\}$, we denote the pair of pricing schemes as (s_A, s_B). In stage 2, the upstream firms in vertically separated supply chains choose the input prices. This timing assumption reflects the fact that the decision to adopt targeted pricing is time-intensive.[3] In stage 3, the downstream firms (or the vertically integrated firms) compete under the pricing schemes established in stage 1. If their pricing schemes are symmetric, (TP, TP) or (UP, UP), they set their prices simultaneously. If the pricing schemes are asymmetric, (TP, UP) or (UP, TP), the firm employing UP sets the uniform price first, then the firm employing TP sets the targeted price. This assumption reflects the fact that targeted pricing is more flexible than uniform pricing and is standard in many previous studies on targeted pricing (Thisse and Vives 1988; Shaffer and Zhang 1995, 2002; Matsumura and Matsushima 2015; Chen et al. 2020). We solve this game using backward induction.

3 Results

We have three cases for the vertical structures of the supply chains: (i) both supply chains are vertically separated, (ii) one supply chain is vertically integrated and the other is vertically separated, and (iii) both supply chains are vertically integrated.

Decisions on the final good prices in the final stage depend on the marginal costs, regardless of whether they are vertically separated or integrated. mc_i denotes the marginal cost of firm Di (or firm Vi) to sell the final good to consumers in the final stage. If supply chain i is vertically separated, firm Di has $mc_i = w_i$; if supply chain i is vertically integrated, then $mc_i = 0$ because the marginal cost of firm Vi is equivalent to that of supply chain i.

[3] Matsumura and Matsushima (2015) argue that targeted pricing requires significant effort, such as introducing devices, which is a long-term and time-consuming investment.

3.1 Case (i): both supply chains are vertically separated.

We consider the case in which both supply chains are vertically separated. Hereafter, we calculate the profits for each pricing scheme: (TP, TP), (TP, UP), (UP, TP), and (UP, UP).

3.1.1 Both downstream firms employ TP.

We suppose that both downstream firms employ TP. In stage 3, the minimum price of firm Di to each consumer is mc_i. Firm DA gains the demand of consumer x if $p_A(x) + tx < mc_B + t(1-x)$; that is, $p_A(x) < mc_B + t(1-2x)$. Therefore, firm DA offers the following price to consumer x.

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

Similarly, firm DB offers the price to consumer x as follows.

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

Thus, the indifferent consumer $\hat{x}^{NN}(TP, TP)$ is obtained as follows:

$$\hat{x}^{NN}(TP, TP) = \frac{t - mc_A + mc_B}{2t},$$

where the superscript NN indicates that both supply chains are vertically separated.

In stage 2, given $mc_A = w_A$ and $mc_B = w_B$, we obtain the profit of each upstream firm. The first-order condition for w_i leads to the following outcomes.

$$w_A^{NN}(TP, TP) = t, \quad w_B^{NN}(TP, TP) = t.$$

Using these outcomes, we obtain the profits of the upstream and downstream firms and consumer surplus as follows:

$$\pi_{Di}^{NN}(TP,TP) = \frac{t}{4}, \quad \pi_{Ui}^{NN}(TP,TP) = \frac{t}{2}, \quad CS^{NN}(TP,TP) = v - \frac{7t}{4}.$$

3.1.2 Only one downstream firm employs TP, while the other employs UP.

We consider the case where firm DA employs TP and firm DB employs UP. Let us consider stage 3. Given the price of firm DB, firm DA obtains the demand of consumer x if $p_A(x) + tx < p_B + t(1-x)$; that is, $p_A(x) < p_B + t(1-2x)$. Therefore, firm DA offers the price to consumer x as follows.

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

Solving $mc_A = p_B + t(1-2x)$, we obtain the indifferent consumer $\hat{x}^{NN}(TP,UP)$ as follows:

$$\hat{x}^{NN}(TP,UP) = \frac{t - mc_A + p_B}{2t}.$$

From the above outcome, the profit of firm DB is expressed as follows.

$$\pi_{DB} = (p_B - mc_B)[1 - \hat{x}^{NN}(TP,UP)] = \frac{(p_B - mc_B)(t + mc_A - p_B)}{2t}.$$

From the first-order condition for p_B, we obtain the following outcome.

$$p_B = \frac{t + mc_A + mc_B}{2}.$$

We consider stage 2. Given $mc_i = w_i$, we have the profit of each upstream firm. The first-order conditions for w_i lead to the following outcomes.

$$w_A^{NN}(TP,UP) = \frac{7t}{3}, \quad w_B^{NN}(TP,UP) = \frac{5t}{3}.$$

Using these outcomes, we obtain each profit and consumer surplus as follows:

$$\begin{aligned}
&\pi_{DA}^{NN}(TP,UP) = \frac{49t}{144}, \quad \pi_{DB}^{NN}(TP,UP) = \frac{25t}{72}, \quad \pi_{UA}^{NN}(TP,UP) = \frac{49t}{36},\\
&\pi_{UB}^{NN}(TP,UP) = \frac{25t}{36}, \quad CS^{NN}(TP,UP) = v - 3t.
\end{aligned}$$

Similarly, we obtain each profit and consumer surplus when firm DA employs UP and firm DB employs TP as follows:

$$\begin{aligned}
&\pi_{DA}^{NN}(UP,TP) = \frac{25t}{72}, \quad \pi_{DB}^{NN}(UP,TP) = \frac{49t}{144}, \quad \pi_{UA}^{NN}(UP,TP) = \frac{25t}{36},\\
&\pi_{UB}^{NN}(UP,TP) = \frac{49t}{36}, \quad CS^{NN}(UP,TP) = v - 3t.
\end{aligned}$$

3.1.3 Both downstream firms employ UP.

We suppose that both downstream firms employ UP. In stage 3, by solving $p_A + tx = p_B + t(1-x)$, we obtain the indifferent consumer $\hat{x}^{NN}(UP,UP)$ as follows.

$$\hat{x}^{NN}(UP,UP) = \frac{t - p_A + p_B}{2t}.$$

From the first-order condition for p_i, we obtain the following outcomes.

$$p_A = \frac{3t + 2mc_A + mc_B}{3}, \quad p_B = \frac{3t + mc_A + 2mc_B}{3}.$$

We consider stage 2. From the above outcomes and $mc_i = w_i$, we obtain each upstream firm's profit. The first-order condition for w_i leads to the following outcomes.

$$w_A^{NN}(UP, UP) = 3t, \quad w_B^{NN}(UP, UP) = 3t.$$

Using the above outcomes, we obtain each profit and consumer surplus as follows:

$$\pi_{Di}^{NN}(UP, UP) = \frac{t}{2}, \quad \pi_{Ui}^{NN}(UP, UP) = \frac{3t}{2}, \quad CS^{NN}(UP, UP) = v - \frac{17t}{4}.$$

3.1.4 Equilibrium pricing scheme

Using the outcomes under each pricing scheme, we obtain the payoff matrix shown in Table 1. In each cell, the left side is the profit of firm DA and the right side is the profit of firm DB. From the payoff matrix in Table 1 and the consumer surplus for each subgame, we

Table 1: Payoff matrix at stage 1 in case (i)

DA/DB	TP	UP
TP	$\frac{t}{4}, \frac{t}{4}$	$\frac{49t}{144}, \frac{25t}{72}$
UP	$\frac{25t}{72}, \frac{49t}{144}$	$\frac{t}{2}, \frac{t}{2}$

obtain Proposition 1.

Proposition 1 *When both supply chains are vertically separated, both downstream firms employ uniform pricing. The pair of pricing schemes realized in equilibrium fails to achieve the highest consumer surplus.*

An intuition behind Proposition 1 is as follows. When the rival supply chain is vertically separated, adopting UP has two effects on own profit. First, adopting UP has the effect of losing demand to the rival, and we call this negative effect the *demand-reduction effect*. Second, the rival upstream firm, faced with a larger demand, offers a higher input price to the rival downstream firm. Thus, adopting UP has the effect of easing downstream competition by putting the rival at a cost disadvantage. We call this positive effect the *input-price effect*. Additionally, because the input-price effect raises the cost of the rival, it also has the role of weakening the demand-reduction effect. In this model, the positive impact of the input-price effect on profit exceeds the negative impact of the demand-reduction effect. Therefore, UP is the optimal pricing scheme when the rival supply chain is vertically separated. Furthermore, as long as the rival supply chain is vertically separated, UP is the dominant strategy, independent of the rival's pricing scheme. Since we now consider the case where both supply chains are vertically separated, both downstream firms adopt UP. Note that, however, the case where both downstream firms employ TP is the most competitive and desirable for consumers.

3.2 Case (ii): one supply chain is vertically integrated and the other is vertically separated.

We consider the case where one supply chain is vertically integrated while the other supply chain is vertically separated. Without loss of generality, we assume that supply chain A is vertically integrated and supply chain B is vertically separated. The calculation process is the same as that in subsection 3.1; thus, we obtain the payoff matrix shown in Table 2. For details of the calculation process, see Appendix. Additionally, we obtain the consumer

Table 2: Payoff matrix at stage 1 in case (ii)

VA/DB	TP	UP
TP	$\frac{9t}{16}, \frac{t}{16}$	$\frac{49t}{64}, \frac{t}{32}$
UP	$\frac{25t}{32}, \frac{9t}{64}$	$\frac{9t}{8}, \frac{t}{8}$

surplus for each subgame as follows:

$$CS^{VN}(TP, TP) = v - \frac{17t}{16}, \quad CS^{VN}(TP, UP) = v - \frac{5t}{4},$$
$$CS^{VN}(UP, TP) = v - \frac{7t}{4}, \quad CS^{VN}(UP, UP) = v - \frac{31t}{16}.$$

Here, the superscript VN indicates that supply chain A is vertically integrated and supply chain B is vertically separated. From the payoff matrix in Table 2 and the consumer surplus under each pricing scheme, we obtain Proposition 2.

Proposition 2 *We consider the case where only one supply chain is vertically integrated and the other supply chain is vertically separated. The vertically integrated firm employs uniform pricing, whereas the downstream firm in the vertically separated supply chain employs targeted pricing. The pair of pricing schemes realized in equilibrium fails to achieve the highest consumer surplus.*

An intuition for Proposition 2 is as follows. First, we consider the vertically integrated firm. This firm's rival supply chain is vertically separated. Therefore, through the same discussion as Proposition 1, the vertically integrated firm adopts UP. Next, we consider why the downstream firm in the vertically separated supply chain adopts TP. The rival supply chain of this firm is vertically integrated, thus the marginal cost of the rival firm is fixed at zero. Therefore, adopting UP by the separated downstream has no input-price effect. Consequently, the demand-reduction effect dominates, resulting in the downstream firm adopting TP. Similar to Proposition 1, the pair in which both firms adopt TP leads to the highest consumer surplus; however, this is not realized in equilibrium.

3.3 Case (iii): both supply chains are vertically integrated.

We consider the case where both supply chains are vertically integrated. The calculation process is almost the same as that described in subsection 3.1, and we obtain the paypff matrix in Table 3. For details on the calculation process, see Appendix. Additionally, we have the consumer surplus under each pricing scheme as follows.

$$CS^{VV}(TP, TP) = v - \frac{3t}{4}, \quad CS^{VV}(TP, UP) = v - t,$$
$$CS^{VV}(UP, TP) = v - t, \quad CS^{VV}(UP, UP) = v - \frac{5t}{4}.$$

Table 3: Payoff matrix at stage 1 in case (iii)

VA/VB	TP	UP
TP	$\frac{t}{4}, \frac{t}{4}$	$\frac{9t}{16}, \frac{t}{8}$
UP	$\frac{t}{8}, \frac{9t}{16}$	$\frac{t}{2}, \frac{t}{2}$

Here, the superscript VV indicates that both supply chains are vertically integrated. From the payoff matrix in Table 3 and the consumer surplus in each subgame, we obtain Proposition 3.

Proposition 3 *When both supply chains are vertically integrated, both vertically integrated firms employ targeted pricing. The pair of pricing schemes realized in equilibrium achieves the highest consumer surplus.*

An intuition behind Proposition 3 is as follows. As both supply chains are vertically integrated, the marginal cost of each vertically integrated firm is zero. Therefore, neither vertically integrated firm has the input-price effect of adopting UP. Thus, both firms choose TP to avoid demand reduction. Proposition 3 is the well-known result in the literature on targeted pricing. Furthermore, we have the highest consumer surplus because the most competitive pricing scheme pair is realized in equilibrium.

From Propositions 1 to 3, we obtain the main result: Corollary 1. The intuition behind Corollary 1 is the same as that discussed in Propositions 1 to 3.

Corollary 1 *Whether targeted or uniform pricing is employed in a supply chain depends on the vertical structure of the rival supply chain. If the rival supply chain is vertically separated, uniform pricing is employed. If the rival supply chain is vertically integrated, targeted pricing is employed.*

We discuss several insights based on the results of Corollary 1. First, our results provide management guidelines for firms considering whether to adopt targeted or uniform pricing. We suggest that firms should confirm the vertical structure of the rival supply chain when deciding on the pricing scheme. Firms can easily obtain information on the vertical structure of their competing supply chains. Thus, our results suggest practical guidelines for these firms. Regarding competition policy, we caution against authorities allowing firms to access consumer data to promote competition. Corollary 1 implies that even if authorities grant firms access to consumer data, they may not adopt targeted pricing; thus, the grant may not promote competition. Given that vertical separation is observed in many industries (Matsushima and Mizuno 2013), the benefits of granting firms access to consumer data may be smaller than previously thought.

4 Robustness and Extensions

4.1 Long-term contracts

In section 3, we obtain the main result that uniform pricing is employed when the rival supply chain is vertically separated. The intuition behind the main result is that uniform pricing raises the rival's input price. We would expect this effect to disappear if the the pricing scheme decision comes after the input pricing. To clarify our intuition, we focus on case (i), the case where both supply chains are vertically separated, and further modify the timing of the game as follows. In stage 1, the upstream firms determine their input prices. In stage 2, the downstream firms simultaneously decide whether to adopt TP or UP. Finally, in stage 3, the downstream firms compete under the pricing schemes established in stage 2. The setup of this extended model is the same as that described in section 2, except for the timing.

In stage 3, using the same calculation process as in section 3, we obtain the profits under each pricing scheme. In stage 2, we obtain the payoff matrix in Table 4 using the outcomes. From the payoff matrix in Table 4, we obtain Proposition 4.

Proposition 4 *We consider the case where both supply chains are vertically separated. If each downstream firm chooses the pricing scheme, targeted pricing or uniform pricing, after*

Table 4: Payoff matrix at stage 2 under long-term contracts

DA/DB	TP	UP
TP	$\frac{(t-w_A+w_B)^2}{4t}, \frac{(t+w_A-w_B)^2}{4t}$	$\frac{(3t-w_A+w_B)^2}{16t}, \frac{(t+w_A-w_B)^2}{8t}$
UP	$\frac{(t-w_A+w_B)^2}{8t}, \frac{(3t+w_A-w_B)^2}{16t}$	$\frac{(3t-w_A+w_B)^2}{18t}, \frac{(3t+w_A-w_B)^2}{18t}$

each upstream firm determines its input price, then both downstream firms employ targeted pricing.

An intuition behind Proposition 4 is as follows. In this extended model, the input prices are already determined and fixed when deciding on the pricing schemes at stage 2. Thus, adopting UP does not lead to a higher input price for the rival downstream firm. As a result, the demand-reduction effect dominates, and we obtain the well-known result that both downstream firms employ TP.

From Proposition 4, we find that the assumption that the downstream firms choose the pricing schemes before the upstream firms determine their input prices is crucial to our main result. Thus, our main result is useful in situations where supply chains do not have long-term contracts for input prices.

4.2 Nash bargaining

The role of input prices is crucial for the intuition of our main model. If the input prices are determined through bargaining within supply chains and the downstream firms have strong bargaining power, then the input prices are close to the upstream marginal costs. In such a situation, changing pricing schemes may not have significant effects on input prices, and thus we expect that the main results would not hold. In this subsection, we discuss this mechanism using Nash bargaining and clarify the applicability of our results.

This extended model is the same as the main model, except that in stage 2, the input prices are determined by Nash bargaining. In stage 2, w_i is decided as follows.

$$\max_{w_i} \beta_i \log \pi_{Ui} + (1-\beta_i) \log \pi_{Di}.$$

$\beta_i \in [0,1]$ is the bargaining power of firm Ui and $(1-\beta_i)$ is that of firm Di. Since firm Di and firm Ui trade exclusively in supply chain i, the outside option of each firm is zero. If we need to express a situation where supply chain i is vertically integrated, we can do so by specifying $\beta_i = 0$ because the input price converges to the upstream firm's marginal cost.

First, we suppose that both downstream firms adopt TP. The outcomes in stage 3 are the same as those in section 3. In stage 2, from the outcomes in stage 3 and $mc_i = w_i$, we obtain the Nash product in this stage. The first-order conditions lead to the input prices that brings the profits as follows.

$$\pi^B_{DA}(TP,TP) = \frac{t(2-\beta_A)^2(2+\beta_B)^2}{4(4-\beta_A\beta_B)^2}, \quad \pi^B_{DB}(TP,TP) = \frac{t(2+\beta_A)^2(2-\beta_B)^2}{4(4-\beta_A\beta_B)^2}.$$

Here, the superscript B denotes Nash bargaining. For asymmetric pricing schemes, a similar procedure yields the following outcomes.

$$\pi^B_{DA}(TP,UP) = \frac{t(2-\beta_A)^2(6+\beta_B)^2}{16(4-\beta_A\beta_B)^2}, \quad \pi^B_{DB}(TP,UP) = \frac{t(2+3\beta_A)^2(2-\beta_B)^2}{8(4-\beta_A\beta_B)^2},$$
$$\pi^B_{DA}(UP,TP) = \frac{t(2-\beta_A)^2(2+3\beta_B)^2}{8(4-\beta_A\beta_B)^2}, \quad \pi^B_{DB}(UP,TP) = \frac{t(6+\beta_A)^2(2-\beta_B)^2}{16(4-\beta_A\beta_B)^2}.$$

Finally, if both downstream firms adopt UP, we obtain the outcomes as follows.

$$\pi^B_{DA}(UP,UP) = \frac{t(2-\beta_A)^2(2+\beta_B)^2}{2(4-\beta_A\beta_B)^2}, \quad \pi^B_{DB}(UP,UP) = \frac{t(2+\beta_A)^2(2-\beta_B)^2}{2(4-\beta_A\beta_B)^2}.$$

We consider two cases: (a) both upstream firms have equal bargaining power, and (b) only one upstream firm has bargaining power fixed at 0. Note that since (b) represents the situation where only one supply chain is vertically integrated, (b) corresponds to case (ii) in the main model.

4.2.1 (a) Both upstream firms have equal bargaining power

We identify the applicability of our result in case (i) by assuming that each upstream firm has equal bargaining power. More precisely, we assume $\beta_A = \beta_B = \beta$. From this assumption and the outcomes in each subgame, we obtain the payoff matrix in Table 5. From the payoff

Table 5: Payoff matrix at stage 1 in case (a)

DA/DB	TP	UP
TP	$\frac{t}{4}, \frac{t}{4}$	$\frac{t(6+\beta)^2}{16(2+\beta)^2}, \frac{t(2+3\beta)^2}{8(2+\beta)^2}$
UP	$\frac{t(2+3\beta)^2}{8(2+\beta)^2}, \frac{t(6+\beta)^2}{16(2+\beta)^2}$	$\frac{t}{2}, \frac{t}{2}$

matrix in Table 5, we obtain Proposition 5.

Proposition 5 *We consider the case where both upstream firms have equal bargaining power. If each upstream firm has large bargaining power,* $(4\sqrt{2} - 2)/7 \approx 0.522 \leq \beta \leq 1$, *both downstream firms employ uniform pricing. If the bargaining power is intermediate,* $(8\sqrt{2} - 10)/7 \approx 0.188 \leq \beta < 0.522$, *there are two equilibria: both downstream firms employ uniform pricing, and both downstream firms employ targeted pricing. If the bargaining power is small,* $0 \leq \beta < 0.188$, *both downstream firms employ targeted pricing.*

Proof. See Appendix.

The intuition behind Proposition 5 is as follows. With $\beta = 1$, this extended model is consistent with case (i) in the main model. Since each downstream firm's profit is continuous with respect to β, the result in case (i) holds for sufficiently large β. Conversely, with $\beta = 0$, it is consistent with case (iii) in the main model. Therefore, for sufficiently small β, the result in case (iii) is valid. Finally, the intermediate β has two equilibria (TP, TP) and (UP, UP). This result is also observed by Matsumura and Matsushima (2015), implying that adopting TP enhances the rival's incentive to adopt TP.

4.2.2 (b) Only one upstream firm has no bargaining power

We analyze the case where one supply chain is vertically integrated and the other engages in Nash bargaining on its input price. We assume that supply chain A is vertically integrated and that supply chain B engages in Nash bargaining. Thus, we consider $\beta_A = 0$ and $\beta_B \in [0, 1]$. This assumption corresponds to case (ii) in the main model.

By applying $\beta_A = 0$ to the outcomes under each subgame, we obtain the payoff matrix in Table 6. From the payoff matrix in Table 6, we obtain Proposition 6.

Table 6: Payoff matrix at stage 1 in case (b)

DA/DB	TP	UP
TP	$\frac{t(2+\beta_B)^2}{16}, \frac{t(2-\beta_B)^2}{16}$	$\frac{t(6+\beta_B)^2}{64}, \frac{t(2-\beta_B)^2}{32}$
UP	$\frac{t(2+3\beta_B)^2}{32}, \frac{9t(2-\beta_B)^2}{64}$	$\frac{t(2+\beta_B)^2}{8}, \frac{t(2-\beta_B)^2}{8}$

Proposition 6 *We consider the case where firm Ui in supply chain i has no bargaining power. Firm Dj always employs targeted pricing. Firm Di employs uniform pricing if firm Uj in supply chain j has large bargaining power,* $(4\sqrt{2} - 2)/7 \approx 0.522 \leq \beta_j \leq 1$. *Otherwise, firm Di employs targeted pricing.*

Proof. See Appendix.

The intuition behind Proposition 6 is as follows. Since we assume $\beta_A = 0$, if $\beta_B = 1$, this extended model is consistent with case (ii) in the main model. Thus, for large β_B, we obtain the same result as in case (ii). Conversely, when $\beta_B = 0$, it is consistent with case (iii) in the main model. Since the profits are continuous for β_B, there exists the threshold value β_B such that to adopt targeted pricing and to adopt uniform pricing are indifferent for firm DB.

4.3 Endogenous vertical structure

This subsection shows that our main result holds when each supply chain endogenously chooses its vertical structure. We modify the main model as follows. At stage 0, each supply chain simultaneously decides whether to vertically integrate (V) or vertically separate (N). In this stage, if $\pi_{Vi} > \pi_{Di} + \pi_{Ui}$, supply chain i chooses vertical integration. Subsequent stages 1 to 3 are the same as stages 1 to 3 in the main model.

Table 7 shows the payoff matrix at stage 0. For each cell, the left and right sides are the total profits in supply chains A and B, respectively. If supply chain i is vertically separated, the total profit is $\pi_{Di} + \pi_{Ui}$; if it is vertically integrated, the total profit is π_{Vi}. From the payoff matrix in Table 7, we obtain Proposition 7.

Table 7: Payoff matrix at stage 0 under endogenous vertical structure

A/B	V	N
V	$\frac{t}{4}, \frac{t}{4}$	$\frac{25t}{32}, \frac{45t}{64}$
N	$\frac{45t}{64}, \frac{25t}{32}$	$2t, 2t$

Proposition 7 *Both supply chains choose vertical separation.*

The intuition behind Proposition 7 is as follows. As shown in the previous studies, vertical separation has the negative effect of losing efficiency in the supply chain and the positive effect of moderating price competition through double marginalization. Additionally, this study shows that vertical separation has another positive effect of inducing the rival to adopt uniform pricing, leading to more moderate price competition. Thus, the positive effects dominate the negative effect, and both supply chains choose vertical separation.

The aforementioned discussion shows that, even if the supply chains can endogenously decide their vertical structures, our main result is still valid because both supply chains choose vertical separation.

5 Conclusion

Recent technological developments have enabled firms to employ targeted pricing. For example, in the U.K. supermarket industry, Tesco and Sainsbury's have implemented targeted pricing. However, firms in certain industries continue to employ uniform pricing (e.g., the soft drink industry). This study analyzes the reasons for these industry-specific differences by considering the competition among supply chains with various vertical structures.

Our main findings are as follows. When the rival supply chain is vertically separated, uniform pricing is optimal because it reduces competition by forcing the rival downstream firm to face larger demand and thus a higher input price. Conversely, when the rival supply chain is vertically integrated, this effect disappears and targeted pricing becomes optimal. In reality, information on the vertical structure of rivals is readily available. Therefore, our results have useful implications for firms considering whether to adopt targeted pricing. Additionally, our study implies that in industries where vertical separation is observed, competition is not promoted, even if authorities grant firms access to consumer data.

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Appendix

A.1 The profits under each pricing scheme in case (ii).

We derive the profits under each pricing scheme for case (ii). For each subgame, in stage 3, the outcomes are the same as those in subsection 3.1. Now, we consider stage 2. First, we suppose that both firms VA and DB adopt TP. Given $mc_A = 0$ and $mc_B = w_B$, we obtain the profit of firm UB. The first-order condition for w_B leads to the input price that brings the following profits.

$$\pi_{VA}^{VN}(TP, TP) = \frac{9t}{16}, \quad \pi_{DB}^{VN}(TP, TP) = \frac{t}{16}, \quad \pi_{UB}^{VN}(TP, TP) = \frac{t}{8}.$$

Similarly, we obtain each profit under the asymmetric pricing schemes as follows.

$$\pi_{VA}^{VN}(TP, UP) = \frac{49t}{64}, \quad \pi_{DB}^{VN}(TP, UP) = \frac{t}{32}, \quad \pi_{UB}^{VN}(TP, UP) = \frac{t}{16},$$

$$\pi_{VA}^{VN}(UP, TP) = \frac{25t}{32}, \quad \pi_{DB}^{VN}(UP, TP) = \frac{9t}{64}, \quad \pi_{UB}^{VN}(UP, TP) = \frac{9t}{16}.$$

Finally, when both firms adopt UP, we obtain each firm's profit as follows.

$$\pi_{VA}^{VN}(UP, UP) = \frac{9t}{8}, \quad \pi_{DB}^{VN}(UP, UP) = \frac{t}{8}, \quad \pi_{UB}^{VN}(UP, UP) = \frac{3t}{8}.$$

Thus, we obtain the payoff matrix shown in Table 2. □

A.2 The profits under each pricing scheme in case (iii).

We derive the profits for each subgame in case (iii). The outcomes of stage 3 are the same as those in subsection 3.1. Given $mc_A = 0$ and $mc_B = 0$, we obtain the profits in each subgame as follows.

$$\pi_{VA}^{VV}(TP,TP)=\frac{t}{4},\quad \pi_{VB}^{VV}(TP,TP)=\frac{t}{4},\quad \pi_{VA}^{VV}(TP,UP)=\frac{9t}{16},\quad \pi_{VB}^{VV}(TP,UP)=\frac{t}{8}.$$

$$\pi_{VA}^{VV}(UP,TP)=\frac{t}{8},\quad \pi_{VB}^{VV}(UP,TP)=\frac{9t}{16},\quad \pi_{VA}^{VV}(UP,UP)=\frac{t}{2},\quad \pi_{VB}^{VV}(UP,UP)=\frac{t}{2}.$$

Using the profit outcomes under each pricing scheme, we obtain the payoff matrix in Table 3. □

A.3 Proof of Proposition 5.

Assuming $\beta_A=\beta_B=\beta$, the profits of the downstream firms under each pricing scheme is as follows.

$$\pi_{Di}^{BE}(TP,TP)=\frac{t}{4},\quad \pi_{DA}^{BE}(TP,UP)=\pi_{DB}^{BE}(UP,TP)=\frac{t(6+\beta)^2}{16(2+\beta)^2},$$
$$\pi_{DA}^{BE}(UP,TP)=\pi_{DB}^{BE}(TP,UP)=\frac{t(2+3\beta)^2}{8(2+\beta)^2},\quad \pi_{Di}^{BE}(UP,UP)=\frac{t}{2}.$$

Here, the superscript BE indicates that both upstream firms have equal bargaining power.

From the above outcomes, we obtain the following results for firm DA.

$$\pi_{DA}^{BE}(TP,TP)>\pi_{DA}^{BE}(UP,TP)\ \text{ if }\ 0\leq\beta<\frac{4\sqrt{2}-2}{7}\approx 0.522.$$
$$\pi_{DA}^{BE}(TP,UP)>\pi_{DA}^{BE}(UP,UP)\ \text{ if }\ 0\leq\beta<\frac{8\sqrt{2}-10}{7}\approx 0.188.$$

As we obtain a similar result for firm DB, we obtain Proposition 5. □

A.4 Proof of Proposition 6.

From $\beta_A = 0$, we obtain the profit of firm DB under each pricing scheme as follows.

$$\pi_{DB}^{BX}(TP,TP) = \frac{t(2-\beta_B)^2}{16}, \quad \pi_{DB}^{BX}(TP,UP) = \frac{t(2-\beta_B)^2}{32},$$
$$\pi_{DB}^{BX}(UP,TP) = \frac{9t(2-\beta_B)^2}{64}, \quad \pi_{DB}^{BX}(UP,UP) = \frac{t(2-\beta_B)^2}{8}.$$

Here, the superscript BX denotes that firm UA has zero bargaining power. From these outcomes, we obtain $\pi_{DB}^{BX}(TP,TP) > \pi_{DB}^{BX}(TP,UP)$ and $\pi_{DB}^{BX}(UP,TP) > \pi_{DB}^{BX}(UP,UP)$. These results imply that TP is the dominant strategy of firm DB. Therefore, (TP,UP) and (UP,UP) are not realized in equilibrium.

Then, because $\beta_A = 0$, the profit of firm DA in each pricing scheme is as follows.

$$\pi_{DA}^{BX}(TP,TP) = \frac{t(2+\beta_B)^2}{16}, \quad \pi_{DA}^{BX}(TP,UP) = \frac{t(6+\beta_B)^2}{64},$$
$$\pi_{DA}^{BX}(UP,TP) = \frac{t(2+3\beta_B)^2}{32}, \quad \pi_{DA}^{BX}(UP,UP) = \frac{t(2+\beta_B)^2}{8}.$$

Using these outcomes, we obtain the following result.

$$\pi_{DA}^{BX}(TP,TP) > \pi_{DA}^{BX}(UP,TP) \text{ if } 0 \leq \beta_B < \frac{4\sqrt{2}-2}{7} \approx 0.522.$$

From the above discussion of firms DA and DB, we obtain Proposition 6. □