Endogenous Market Structure with Upstream Corporate Social Responsibility

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April 2025

Discussion Paper No. 2509

GRADUATE SCHOOL OF ECONOMICS

KOBE UNIVERSITY

ROKKO, KOBE, JAPAN

Endogenous Market Structure with Upstream Corporate Social Responsibility*

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April 2, 2025

Abstract

Firms in many industries engage in corporate social responsibility (CSR). We consider a vertical market with one upstream firm committed to CSR and two downstream firms providing differentiated goods, and analyze the endogenous market structure (Cournot, Bertrand, or Cournot-Bertrand competition) between the downstream firms. Contrary to conventional wisdom, we show that Bertrand competition emerges in the downstream market when the degree of upstream CSR is high. Under Bertrand competition, consumer surplus is larger, and the upstream firm with CSR prioritizes consumer surplus, which results in a lower input price. Consequently, downstream firms earn higher profits under Bertrand competition.

JEL codes: D43, L10, L13.

Keywords: endogenous market structure, corporate social responsibility, vertical relationship, Cournot competition, Bertrand competition.

*The authors gratefully acknowledge financial support from JST SPRING, Grant Number JPMJSP2148. The usual disclaimer applies.

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1 Introduction

The market structure of an industry (ie., whether Cournot or Bertrand) fundamentally shapes the intensity of competition and determines the sizes of consumer and total surpluses. Therefore, it is important to identify the market structure of an industry. Singh and Vives (1984), a seminal paper, analyzed endogenous market structure and showed that Cournot competition is realized when goods are substitutable. In contrast, a number of studies challenge the well-known result by considering various factors (Basak and Wang 2016; Chirco and Scrimitore 2013; Correa-López 2007; Hu et al. 2024; Mastumura and Ogawa 2012; Pal 2015; Scrimitore 2013).

In recent years, corporate social responsibility (CSR) has become an essential element of firms; thus, many researchers have focused on it (Cho et al., 2019; Fanti and Buccella 2019; Fernández-Ruiz, 2021; García et al., 2019; Matsumura and Ogawa 2014; Qian et al., 2021).[1] Hence, the role of CSR in the endogenous market structure has been analyzed extensively (Fanti and Buccella 2018; Kopel 2015; Nakamura 2023a; Nakamura 2023b; Matsumuta and Ogawa 2016). This study focuses on CSR of an upstream firm, which these studies have not analyzed. As mentioned above, many firms are required by society to engage in CSR, and an upstream firm is particularly likely to engage in CSR because the upstream market is at the core of its production (Masuyama 2024; Xue et al., 2023). We propose that the upstream firm's CSR activity plays an important role in the endogenous market structure.

We consider a vertical market with an upstream firm engaged in CSR and two profit-maximizing downstream firms. The downstream firms purchase inputs from the upstream firm to produce horizontally differentiated goods. The upstream firm uses consumer surplus as an indicator of CSR. Before starting the production process, the downstream firms choose the type of contract: quantity or price. If the downstream firms

[1] Empirical studies on CSR include Benkraiem et al. (2022); Hong et al. (2022); Jian et al. (2023), Sun et al. (2024); Wu and Chen (2023), and Xue (2023).

choose quantity contracts, Cournot competition occurs; if they choose price contracts, Bertrand competition occurs; and if the downstream firms choose different contracts, Cournot-Bertrand competition occurs.

Our findings are as follows: When the degree of upstream CSR is sufficiently high, both downstream firms choose price contracts, thereby realizing Bertrand competition; when the degree of upstream CSR is intermediate, Cournot-Bertrand competition occurs; and when the degree of upstream CSR is low, Cournot competition occurs. These results differ from those reported by Singh and Vives (1984).

The intuition behind our main results is as follows. The upstream firm engaging in CSR has two objectives: profit and consumer surplus. The upstream firm considers which of these objectives is easier to achieve. Bertrand competition is the most competitive, making it easier to increase consumer surplus and reduce profit. Therefore, under Bertrand competition, the upstream firm tends to focus on consumer surplus, and consequently, sets a lower input price. The reduction in final goods prices owing to Bertrand competition reduces downstream firms' profits; however, a reduction in input price increases downstream firms' profits. As the degree of upstream CSR is high, the input price reduction effect becomes large. Then, both downstream firms choose price contracts in equilibrium and Bertrand competition is realized.

In the context of the endogenous market structure, many studies revisit the result of Singh and Vives (1984) by considering various factors. Basak and Wang (2016) consider a two-part tariff through centralized Nash bargaining. Chirco and Scrimitore (2013) focus on delegation and network externalities. Correa-López (2007) considers labor unions. Hu et al. (2024) also consider upstream advertising. Matsumura and Ogawa (2012) analyze a mixed duopoly. Pal (2015) considers relative performance delegation and network externalities. Scrimitore (2013) considers subsidized firms in a mixed duopoly. This study contributes to this stream of literature by considering upstream CSR, which these studies have not considered.

Several studies consider CSR within the framework of endogenous market structure.[2] Fanti and Buccella (2018) consider duopolistic firms committed to CSR. Kopel (2015) considers a duopoly market in which only one firm engages in CSR. Nakamura (2023a) assumes that CSR indicators differ across firms, with one firm using consumer surplus and another using total surplus. Nakamura (2023b) considers a situation in which managers have a bias against the market size. Matsumura and Ogawa (2016) focus on the heterogeneity in CSR degrees across firms. However, these studies do not consider upstream CSR.

Our study is also related to those that do not analyze the endogenous market structure but focus on upstream CSR. Using a model similar to ours, Masuyama (2024) analyzes the endogenous timing of downstream firms and shows that upstream CSR may realize sequential competition in quantity competition. However, Masuyama (2024) assumes that the contract type is exogenous and does not consider an endogenous market structure. Xue et al. (2023) is also closely related to our study. They assume that trade between upstream and downstream firms is determined by two-part tariffs, and show that Cournot competition is desirable for downstream firms. By contrast, our study assumes a wholesale contract, indicating that Bertrand competition may be desirable for downstream firms. Furthermore, Xue et al. (2023) do not analyze the endogenous market structure on which we focus.

The remainder of this paper is organized as follows. The next section describes our proposed model. In Section 3, we calculate the equilibrium. Section 4 extends the main model in several ways. Finally, in Section 5, we present our conclusions.

2 Model

We consider a vertical market with one upstream firm U and two downstream firms Di ($i = 1, 2$). Firm U produces an input at a constant marginal cost, which is normalized

[2] Sharma and Rastogi (2024) focus on environmental CSR under endogenous market structure.

to 0, and sells it to the downstream firms at input price w. Each downstream firm uses one unit of the input to produce one unit of the differentiated good sold to consumers.

Following Singh and Vives (1984), we define a representative consumer's utility function as follows:

$$u(q_1, q_2) = q_1 + q_2 - \frac{q_1^2 + 2\gamma q_1 q_2 + q_2^2}{2} - p_1 q_1 - p_2 q_2,$$

where p_i and q_i denote the price and quantity of firm Di, respectively, $\gamma \in (0, 1)$ denotes the substitutability of the goods. Based on this utility function, we obtain the demand functions for firm Di as follows: $q_1(p_1, p_2) = (1 - \gamma - p_1 + \gamma p_2)/(1 - \gamma^2)$ and $q_2(p_2, p_1) = (1 - \gamma - p_2 + \gamma p_1)/(1 - \gamma^2)$.

We define the profits of firms Di and U as follows.

$$\pi_{Di} = (p_i - w)q_i, \quad \pi_U = wQ,$$

where $Q = q_1 + q_2$.

The consumer surplus is $CS = (q_1^2 + 2\gamma q_1 q_2 + q_2^2)/2$. Following the CSR literature (Chen et al. 2022; Cho et al. 2019; Fanti and Buccella 2018; Fernández-Ruiz 2021; Li and Zhou 2019), we define the objective function of firm U as follows:

$$V_U = (1 - \theta)\pi_U + \theta CS,$$

where θ denotes the degree of firm U's CSR. We assume $\theta \in [0, \theta^H)$ to guarantee a positive equilibrium profit for firm U, where $\theta^H = (2 - \gamma)/(3 - \gamma)$. In the main model, we employ CS as the indicator of CSR, and in subsection 4.1, we discuss the case in which the CSR indicator is the total surplus.

The timing of the game is as follows: In stage 1, the downstream firms choose their contract types (quantity or price); in stage 2, firm U chooses w to maximize V_U; and in stage 3, the downstream firms compete under the contract types established in stage 1. We solve this game using backward induction.

3 Main results

3.1 Subgame with Bertrand competition

We consider the case in which both downstream firms choose price contracts. In stage 3, by substituting the demand functions into π_{Di}, the first-order conditions lead to the following outcomes:

$$p_i^B(w) = \frac{1-\gamma+w}{2-\gamma},$$

where the superscript B indicates Bertrand competition.

In stage 2, by substituting $p_i^B(w)$ into V_U, the first-order condition leads to the following outcome:

$$w^B = \frac{2-\gamma-(3-\gamma)\theta}{4-2\gamma-(5-2\gamma)\theta}$$

Therefore, the outcomes of this subgame are as follows.

$$q_i^B = \frac{1-\theta}{(1+\gamma)[4-2\gamma-(5-2\gamma)\theta]}, \quad \pi_{Di}^B = \frac{(1-\gamma)(1-\theta)^2}{(1+\gamma)[4-2\gamma-(5-2\gamma)\theta]^2}$$
$$\pi_U^B = \frac{2(1-\theta)[2-\gamma-(3-\gamma)\theta]}{(1+\gamma)[4-2\gamma-(5-2\gamma)\theta]^2}.$$

3.2 Subgame with Cournot competition

We consider the case in which both downstream firms choose quantity contracts. Solving $q_1(p_1, p_2)$ and $q_2(p_2, p_1)$ for p_1 and p_2, we obtain the inverse demand functions: $p_1(q_1, q_2) = 1 - q_1 - \gamma q_2$ and $p_2(q_2, q_1) = 1 - q_2 - \gamma q_1$. In stage 3, by substituting the inverse demand functions into π_{Di}, the first-order conditions lead to the following outcomes:

$$q_i^C(w) = \frac{1-w}{2+\gamma},$$

where the superscript C denotes Cournot competition.

In stage 2, by substituting $q_i^C(w)$ into V_U, the first-order condition leads to the following outcome:

$$w^C = \frac{2+\gamma-(3+2\gamma)\theta}{4+2\gamma-(5+3\gamma)\theta}.$$

Using the above outcomes, the outcomes of this subgame are as follows:

$$q_i^C = \frac{1-\theta}{4+2\gamma-(5+3\gamma)\theta}, \quad \pi_{Di}^C = \frac{(1-\theta)^2}{[4+2\gamma-(5+3\gamma)\theta]^2}$$
$$\pi_U^C = \frac{2(1-\theta)[2+\gamma-(3+2\gamma)\theta]}{[4+2\gamma-(5+3\gamma)\theta]^2}.$$

3.3 Subgame with Cournot-Bertrand competition

We now consider the case in which the chosen contract types are asymmetric. Without loss of generality, we focus on the case in which firm $D1$ chooses a quantity contract, and firm $D2$ chooses a price contract. Solving for $q_1(p_1, p_2)$ and $q_2(p_2, p_1)$ on p_1 and q_2, we obtain the following inverse and demand functions: $p_1(q_1, p_2) = 1-\gamma-q_1(1-\gamma^2)+p_2\gamma$ and $q_2(p_2, q_1) = 1-p_2-q_1\gamma$. By substituting these into each downstream firm's profit, the first-order conditions lead to the following outcomes:

$$q_1^{CB}(w) = \frac{(2-\gamma)(1-w)}{4-3\gamma^2}, \quad p_2^{CB}(w) = \frac{2-\gamma-\gamma^2+(2+\gamma-2\gamma^2)w}{4-3\gamma^2}.$$

Here, the superscript CB indicates that firm $D1$ chooses a quantity contract and firm $D2$ chooses a price contract.

Using the outcomes above, the first-order condition yields the following input price:

$$w^{CB} = w^{BC} = \frac{4-2\gamma-\gamma^2-(6-2\gamma-2\gamma^2)\theta}{8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta},$$

where the superscript BC indicates that firm $D1$ chooses a price contract, and firm $D2$ chooses a quantity contract. Therefore, we obtain the following outcomes for each subgame in stage 2:

$$
\begin{aligned}
q_1^{CB} = q_2^{BC} &= \frac{(1-\theta)(8-8\gamma+\gamma^3)}{(4-3\gamma^2)[8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]}, \\
q_2^{CB} = q_1^{BC} &= \frac{(1-\theta)(8-8\gamma-4\gamma^2+3\gamma^3+\gamma^4)}{(4-3\gamma^2)[8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]}, \\
\pi_{D1}^{CB} = \pi_{D2}^{BC} &= \frac{(1-\gamma^2)(1-\theta)^2(8-8\gamma+\gamma^3)^2}{(4-3\gamma^2)^2[8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]^2}, \\
\pi_{D2}^{CB} = \pi_{D1}^{BC} &= \frac{(1-\theta)^2(8-8\gamma-4\gamma^2+3\gamma^3+\gamma^4)^2}{(4-3\gamma^2)^2[8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]^2} \\
\pi_U^{CB} = \pi_U^{BC} &= \frac{(4-2\gamma-\gamma^2)^2(1-\theta)[4-2\gamma-\gamma^2-(6-2\gamma-2\gamma^2)\theta]}{(4-3\gamma^2)[8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]^2}.
\end{aligned}
$$

Before moving on to the analysis of stage 1, we compare the total output and input price in each subgame. Comparing the total output in each subgame, we obtain Lemma 1.

Lemma 1 *The total output is the largest in Bertrand competition and the smallest in Cournot competition:* $Q^C < Q^{CB} = Q^{BC} < Q^B$.

Proof. See Appendix.

Lemma 1 shows that the well-known basic properties hold even in our model. Downstream competition intensifies when firms choose price contracts. Thus, the case in which both downstream firms choose price contracts leads to the largest total output.

Next, comparing the input prices in each subgame yields Lemma 2.

Lemma 2 *(i) The input price is the lowest in Bertrand competition and the highest in Cournot competition:* $w^B < w^{CB} = w^{BC} < w^C$. *(ii) When the degree of upstream CSR increases, the input price decreases most significantly under Bertrand competition and most moderately under Cournot competition:* $\partial w^B/\partial\theta < \partial w^{CB}/\partial\theta = \partial w^{BC}/\partial\theta < \partial w^C/\partial\theta$.

Proof. See Appendix.

The intuition behind Lemma 2 (i) is as follows: From Lemma 1, the total output is the largest under Bertrand competition and the smallest under Cournot competition. Under Bertrand competition, the upstream firm finds it difficult to increase its profit but easy to increase the consumer surplus. In this case, the upstream firm attempts to reduce the input price and increase the consumer surplus to achieve its own objective. Therefore, the input price under Bertrand competition is the lowest and that under Cournot competition is the highest.

Next, we discuss Lemma 2 (ii). When the degree of upstream CSR is higher, the aforementioned effect is even larger. Therefore, as the degree of upstream CSR increases, the input price declines most significantly under Bertrand competition, and most moderately under Cournot competition.

3.4 Endogenous market structure

In stage 1, the downstream firms choose either quantity or price contracts. From the subgame outcomes, we obtain the following results for firm $D1$.

$$\begin{aligned}
&\pi_{D1}^{CB} < \pi_{D1}^{B},\ \pi_{D1}^{C} < \pi_{D1}^{BC} \text{ if } \theta^{**} < \theta < \theta^{H}, \\
&\pi_{D1}^{B} \leq \pi_{D1}^{CB},\ \pi_{D1}^{C} < \pi_{D1}^{BC} \text{ if } \theta^{*} < \theta \leq \theta^{**}, \quad \text{and} \\
&\pi_{D1}^{B} < \pi_{D1}^{CB},\ \pi_{D1}^{BC} \leq \pi_{D1}^{C} \text{ if } 0 < \theta \leq \theta^{*},
\end{aligned}$$

where $\theta^* = (8\gamma - 4\gamma^2 - 2\gamma^3)/(2 + 9\gamma - 5\gamma^2 - 3\gamma^3)$, $\theta^{**} = (8\gamma - 4\gamma^2 - 2\gamma^3)/(2 + 9\gamma - 6\gamma^2 - 2\gamma^3)$. Using symmetry between downstream firms, we obtain a similar result for firm $D2$, which leads to Proposition 1:

Proposition 1 *When the degree of upstream CSR is sufficiently high, $\theta^{**} < \theta < \theta^H$, both downstream firms choose price contracts. When the degree of upstream CSR is intermediate, $\theta^* < \theta \leq \theta^{**}$, one downstream firm chooses a price contract and the other chooses a quantity contract. Otherwise, both downstream firms choose quantity contracts.*

Proof. See Appendix.

Figure 1 shows the arguments for Proposition 1. The horizontal axis represents the substitutability of goods γ, and the vertical axis represents the degree of upstream CSR θ. Solid blue, black, and dashed curves represent θ^H, θ^{**}, and θ^*, respectively. We consider only the lower region of the solid blue curve because the upper gray region does not yield positive equilibrium outcomes. In the left side area surrounded by solid blue and solid black curves, Bertrand competition is realized. Cournot-Bertrand competition occurs in the middle area, which is surrounded by three curves. In the right side, Cournot competition emerges.

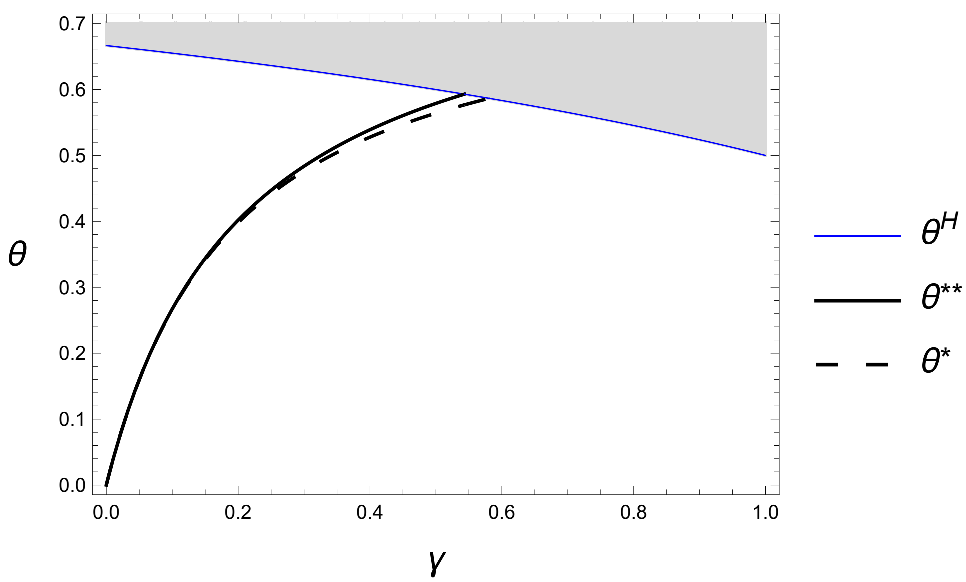


Figure 1: Threshold values for endogenous market structure.

Using Figure 1, we discuss the intuition behind Proposition 1. Choosing a price contract has two effects: the competition effect, in which competition intensifies, and the input price reduction effect, as shown in Lemma 2. When the degree of upstream CSR is sufficiently high, the input price reduction effect is large. In addition, when the substitutability of goods is low, the competition effect is small. Thus, on the left side area of Figure 1, Bertrand competition occurs because the input price reduction effect dominates the competition effect. Next, when the degree of upstream CSR is sufficiently low and the substitutability of goods is high, the input price reduction effect is small, and the competition effect is large. Thus, on the right side area of Figure 1, Cournot competition is realized because the competition effect dominates the input price reduction effect.

Finally, in the middle region of Figure 1, under the intermediate degree of upstream CSR and the intermediate level of substitutability, Cournot-Bertrand competition emerges. The intuition for this is as follows. For Cournot-Bertrand competition to arise, the reduction in input price when transitioning from Cournot to Cournot-Bertrand competition must be greater than when transitioning from Cournot-Bertrand to Bertrand competition. According to Lemma 2, the former shift requires a greater increase in total output than the latter shift. The former shift marks the first emergence of a competitive firm, leading to a significant increase in total output. As a result, because the former shift leads to a more substantial reduction in the input price, we have an area where Cournot-Bertrand competition occurs.

4 Extensions

4.1 Another CSR indicator: total surplus

In Section 3, we assume that the indicator of CSR is the consumer surplus. Some studies consider the case in which the CSR indicator is the total surplus (Hino and Zennyo 2017; Matsumuta and Ogawa 2014). In this subsection, we analyze the case in which the CSR indicator is the total surplus. We denote the total surplus as $TS = CS + \pi_U + \pi_{D1} + \pi_{D2}$. Thus, the objective function of firm U is $V_U = (1-\theta)\pi_U + \theta TS$. Except for this, the setting is the same as that of the main model.

Stage 3 is identical to that of the main model. Therefore, by substituting the outcomes in stage 3 of the main model into the objective function of firm U, the first-order condition yields the outcome of each subgame as follows:

$$w^{TB}=\frac{2-\gamma-(3-2\gamma)\theta}{4-2\gamma-(3-2\gamma)\theta},\quad w^{TC}=\frac{2+\gamma-(3+\gamma)\theta}{4+2\gamma-(3+\gamma)\theta},\quad \text{and}$$
$$w^{TCB}=w^{TBC}=\frac{4-2\gamma-\gamma^2-(6-4\gamma-\gamma^2)\theta}{8-4\gamma-2\gamma^2-(6-4\gamma-\gamma^2)\theta}.$$

Here, the superscript T denotes that the indicator of CSR is the total surplus. Using these outcomes, we derive the downstream firms' profits in each subgame as follows:

$$\pi_{Di}^{TB}=\frac{1-\gamma}{(1+\gamma)[4-2\gamma-(3-2\gamma)\theta]^2},\quad \pi_{Di}^{TC}=\frac{1}{[4+2\gamma-(3+\gamma)\theta]^2},$$
$$\pi_{D1}^{TCB}=\pi_{D2}^{TBC}=\frac{(1-\gamma)(1+\gamma)(8-8\gamma+\gamma^3)^2}{(4-3\gamma^2)^2[8-4\gamma-2\gamma^2-(6-4\gamma-\gamma^2)\theta]^2},\quad \text{and}$$
$$\pi_{D2}^{TCB}=\pi_{D1}^{TBC}=\frac{(1-\gamma)^2(2+\gamma)^2(4-2\gamma-\gamma^2)^2}{(4-3\gamma^2)^2[8-4\gamma-2\gamma^2-(6-4\gamma-\gamma^2)\theta]^2}.$$

We consider stage 1. Using the outcomes of stage 2, we obtain the following profit results.

$$\pi_{D1}^{TB}<\pi_{D1}^{TCB}(\text{similarly } \pi_{D2}^{TB}<\pi_{D2}^{TBC}),\quad \pi_{D1}^{TBC}<\pi_{D1}^{TC}(\text{similarly } \pi_{D2}^{TCB}<\pi_{D2}^{TC})\quad \text{for any}\quad \theta.$$

Therefore, we obtain Proposition 2 as follows:

Proposition 2 *When the indicator of upstream CSR is the total surplus, both downstream firms always choose quantity contracts.*

Proof. See Appendix.

Proposition 2 implies that our main result is invalid when the indicator of upstream CSR is the total surplus. Therefore, what firms adopt as an indicator of CSR is critical to our main results.

4.2 Upstream and Downstream CSR

While in Section 3, we discuss the situation with upstream CSR, here, we analyze a model in which both upstream and downstream firms commit to CSR, and demonstrate that Bertrand competition can be realized.

We define the objective function of firm Di as follows.

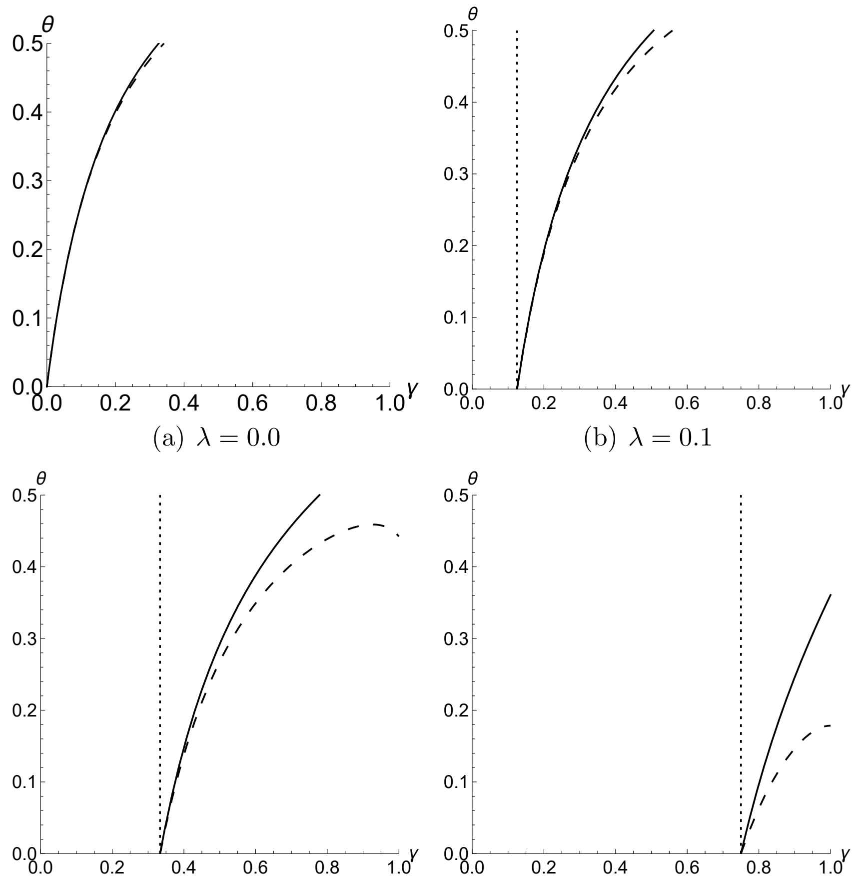
$$V_{Di} = (1 - \lambda)\pi_{Di} + \lambda CS,$$

where λ denotes the degree of downstream CSR. For simplicity, we assume $\theta \in [0, 1/2)$ as a sufficient condition to guarantee a positive input price, and $\lambda \in [0, 1/3)$ as a sufficient condition to guarantee positive downstream markups. In this subsection, as in the main model, we assume that the indicators of upstream and downstream CSR are the consumer surplus.

Although the formulas for the downstream firms' profits and the consumer surplus in each subgame are complicated, the derivation process is the same as in Section 3. By comparing the objective functions of the downstream firms in each case numerically, we obtain an equilibrium pair of contracts in the first stage.

Figure 2 presents a numerical comparison of the downstream firms' objective functions. The horizontal axis represents the substitutability of goods γ, and the vertical axis represents the degree of upstream CSR θ. In (a), (b), (c), and (d) of Figure 2, we consider cases where the degrees of downstream CSR are $\lambda = 0$, $\lambda = 0.1$, $\lambda = 0.2$, and $\lambda = 0.3$, respectively. Figure 2 (a) is the same as Figure 1 in Section 3 because $\lambda = 0$. In (b), (c), and (d), Bertrand competition occurs in the area between the dotted and solid curves and Cournot-Bertrand competition appears in the area between the solid and dashed curves. Otherwise, Cournot competition is realized in both the leftmost and rightmost areas where γ is sufficiently small or large.

We consider the intuition behind Figure 2. For $\lambda > 0$, Cournot competition is realized on the left and right sides. The difference from Section 3 is that Cournot competition occurs on the left side. Thus, we discuss the intuition that Cournot competition is realized when the substitutability of goods γ is sufficiently small. When firms committed to CSR compete, Cournot competition leads to larger total output than Bertrand competition when the substitutability of goods is low and the degree of CSR is high. This finding is consistent with the results of Fanti and Buccella (2018). The intuition behind



(a) $\lambda = 0.0$ (b) $\lambda = 0.1$

(c) $\lambda = 0.2$ (d) $\lambda = 0.3$

Figure 2: Threshold values in the first stage with upstream and downstream CSR.

this is as follows. When the competition mode determines total output size, we have the following two factors: The first is that Bertrand competition is more competitive than Cournot competition and, therefore, has a larger total output. As mentioned in Singh and Vives (1984), the second is that the contribution of a firm's increased quantity to total output is larger under Cournot competition than under Bertrand competition. Under Cournot competition, a firm increases its quantity without changing that of its rival. By contrast, under Bertrand competition, the firm decreases its price given its rival's price, thus increasing its quantity while stealing its rival's demand. Therefore, under Cournot competition, a firm's output expansion is more likely to be reflected in an increase in total output than under Bertrand competition.

When the substitutability of goods is low, the first factor is limited, because the equilibrium prices and quantities under each competition mode differ only slightly. Furthermore, when the degree of CSR is high, the second factor is emphasized. From the above discussion, when the substitutability of goods is low and the degree of downstream CSR is high, the second factor dominates. Thus, the total output under Cournot competition is larger than that under Bertrand competition. Now, when we consider an upstream firm committed to CSR, it offers a lower input price for a larger total output, as seen in Lemma 1. Therefore, in this case, the downstream firms prefer Cournot competition to benefit from the lower input price. Consequently, Cournot competition occurs on the left side of (b), (c), and (d) in Figure 2.

5 Conclusions

This study considers a vertical market involving an upstream firm committed to CSR and two downstream firms. We analyze the endogenous market structure of downstream firms and obtain the following results: When the degree of upstream CSR is high, each downstream firm tends to choose a price contract. Choosing a price contract leads to intense competition; thus, the upstream firm with CSR will set a lower input price to maintain total output. The downstream firms choose price contracts to benefit from the lower input price. Therefore, Bertrand competition occurs when the degree of upstream CSR is high.

This study does not address input price discrimination by an upstream firm or upstream competition. Under input price discrimination, the effect of the lower input price on price contracts may weaken. Additionally, we assume a monopoly in the upstream market. To extend the applicability of our results, it would be valuable to consider competition in the upstream market. These extensions are left for future research.

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Appendix

Proof for Lemma 1.

By calculating $Q^B - Q^{CB}$ and $Q^{CB} - Q^C$, we obtain the following results:

$$Q^B - Q^{CB} = \frac{(1-\gamma)\gamma^2(1-\theta)[16-8\gamma^2-2\gamma^3-(16-7\gamma^2-2\gamma^3)\theta]}{(1+\gamma)(4-3\gamma^2)[4-2\gamma-(5-2\gamma)\theta][8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]} > 0,$$
$$Q^{CB} - Q^C = \frac{\gamma^2(1-\theta)[16-16\gamma+2\gamma^3-(16-16\gamma-\gamma^2+3\gamma^3)\theta]}{[(4-3\gamma^2)][4+2\gamma-(5+3\gamma)\theta][8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]} > 0. \ \square$$

Proof for Lemma 2.

First, by calculating $w^C - w^{CB}$ and $w^{CB} - w^B$, we obtain the following results.

$$w^C - w^{CB} = \frac{\gamma^2(1-\theta)\theta}{[4+2\gamma-(5+3\gamma)\theta][8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]} > 0,$$
$$w^{CB} - w^B = \frac{(1-\gamma)\gamma^2(1-\theta)\theta}{[4-2\gamma-(5-2\gamma)\theta][8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]} > 0.$$

Therefore, Lemma 2 (i) is obtained.

Next, by calculating $\partial w^C/\partial\theta - \partial w^{CB}/\partial\theta$, the following result is obtained:

$$\frac{\partial w^C}{\partial\theta} - \frac{\partial w^{CB}}{\partial\theta} = \frac{\gamma^2[32-16\gamma^2-4\gamma^3-(64-32\gamma^2-8\gamma^3)\theta+(30-2\gamma-15\gamma^2-3\gamma^3)\theta^2]}{[4+2\gamma-(5+3\gamma)\theta]^2[8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]^2}.$$

The sign of $\partial w^C/\partial\theta - \partial w^{CB}/\partial\theta$ corresponds to the square bracket in the numerator. Thus, if $\theta < \theta_1 = 2(16-8\gamma^2-2\gamma^3-\sqrt{16+16\gamma-16\gamma^2-18\gamma^3+2\gamma^4+5\gamma^5+\gamma^6})/(30-2\gamma-15\gamma^2-3\gamma^3)$ or $\theta > \theta_2 = 2(16-8\gamma^2-2\gamma^3+\sqrt{16+16\gamma-16\gamma^2-18\gamma^3+2\gamma^4+5\gamma^5+\gamma^6})/(30-2\gamma-15\gamma^2-3\gamma^3)$, we obtain $\partial w^C/\partial\theta - \partial w^{CB}/\partial\theta > 0$. From $0 < \theta_H < \theta_1 < \theta_2$, we have $\partial w^C/\partial\theta - \partial w^{CB}/\partial\theta > 0$ for any $\gamma \in (0,1)$.

Finally, by calculating $\partial w^{CB}/\partial\theta - \partial w^B/\partial\theta$, we obtain the following result:

$$\frac{\partial w^{CB}}{\partial\theta} - \frac{\partial w^B}{\partial\theta} = \frac{(1-\gamma)\gamma^2[32-32\gamma+4\gamma^3-(64-64\gamma+8\gamma^3)\theta+(30-32\gamma+\gamma^2+4\gamma^3)\theta^2]}{[4-2\gamma-(5-2\gamma)\theta]^2[8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]^2}.$$

The sign of $\partial w^{CB}/\partial\theta - \partial w^B/\partial\theta$ corresponds to the bracket in the numerator. Therefore, if $\theta < \theta_3 = 2(16-16\gamma+2\gamma^3-\sqrt{16-16\gamma-8\gamma^2+10\gamma^3-\gamma^5})/(30-32\gamma+\gamma^2+4\gamma^3)$ or

$\theta > \theta_4 = 2(16-16\gamma+2\gamma^3+\sqrt{16-16\gamma-8\gamma^2+10\gamma^3-\gamma^5})/(30-32\gamma+\gamma^2+4\gamma^3)$, we have $\partial w^{CB}/\partial\theta - \partial w^B/\partial\theta > 0$. From $0 < \theta^H < \theta_3 < \theta_4$, we obtain $\partial w^{CB}/\partial\theta - \partial w^B/\partial\theta > 0$ for any $\gamma \in (0,1)$. From the aforementioned, we obtain Lemma 2 (ii). □

Proof for Proposition 1.

First, calculating $\pi_{D1}^B - \pi_{D1}^{CB}$ yields the following:

$$\pi_{D1}^B - \pi_{D1}^{CB} = \frac{(1-\gamma)\gamma^2(1-\theta)^2\begin{bmatrix} -8\gamma+4\gamma^2+2\gamma^3+ \\ (2+9\gamma-6\gamma^2-2\gamma^3)\theta \end{bmatrix}\begin{bmatrix} 64-32\gamma-64\gamma^2+32\gamma^3 \\ +8\gamma^4-2\gamma^5-(80-32\gamma \\ -82\gamma^2+33\gamma^3+12\gamma^4-2\gamma^5)\theta \end{bmatrix}}{(1+\gamma)(4-3\gamma^2)^2[4-2\gamma-(5-2\gamma)\theta]^2[8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]^2}.$$

For any $\theta \in [0, \theta^H)$, we have $64-32\gamma-64\gamma^2+32\gamma^3+8\gamma^4-2\gamma^5-(80-32\gamma-82\gamma^2+33\gamma^3+12\gamma^4-2\gamma^5)\theta > 0$. Thus, the sign of $\pi_{D1}^B - \pi_{D1}^{CB}$ corresponds to the first square bracket in the numerator. Solving $-8\gamma+4\gamma^2+2\gamma^3+(2+9\gamma-6\gamma^2-2\gamma^3)\theta > 0$, we obtain $\theta > \theta^{**} = (8\gamma-4\gamma^2-2\gamma^3)/(2+9\gamma-6\gamma^2-2\gamma^3)$.

Second, calculating $\pi_{D1}^{BC} - \pi_{D1}^C$ yields the following:

$$\pi_{D1}^{BC} - \pi_{D1}^C = \frac{\gamma^2(1-\theta)^2\begin{bmatrix} -8\gamma+4\gamma^2+2\gamma^3+ \\ (2+9\gamma-5\gamma^2-3\gamma^3)\theta \end{bmatrix}\begin{bmatrix} 64-32\gamma-64\gamma^2+16\gamma^3 \\ +16\gamma^4+2\gamma^5-(80-32\gamma \\ -86\gamma^2+15\gamma^3+23\gamma^4+3\gamma^5)\theta \end{bmatrix}}{(4-3\gamma^2)^2[4+2\gamma-(5+3\gamma)\theta]^2[8-4\gamma-2\gamma^2-(10-4\gamma-3\gamma^2)\theta]^2}.$$

For any $\theta \in [0, \theta^H)$, we obtain $64-32\gamma-64\gamma^2+16\gamma^3+16\gamma^4+2\gamma^5-(80-32\gamma-86\gamma^2+15\gamma^3+23\gamma^4+3\gamma^5)\theta > 0$. Therefore, the sign of $\pi_{D1}^{BC} - \pi_{D1}^C$ corresponds to the first square bracket in the numerator. Solving $-8\gamma+4\gamma^2+2\gamma^3+(2+9\gamma-5\gamma^2-3\gamma^3)\theta > 0$, we have $\theta > \theta^* = (8\gamma-4\gamma^2-2\gamma^3)/(2+9\gamma-5\gamma^2-3\gamma^3)$. From this, we obtain Proposition 1. □

Proof for Proposition 2.

First, by calculating $\pi_{D1}^{TCB} - \pi_{D1}^{TB}$, we obtain the following:

$$\pi_{D1}^{TCB} - \pi_{D1}^{TB} = \frac{(1-\gamma)\gamma^2\begin{bmatrix} 8\gamma-4\gamma^2-2\gamma^3+ \\ (2-7\gamma+2\gamma^2+2\gamma^3)\theta \end{bmatrix}\begin{bmatrix} 64-32\gamma-64\gamma^2+32\gamma^3 \\ +8\gamma^4-2\gamma^5-(48-32\gamma \\ -46\gamma^2+31\gamma^3+4\gamma^4-2\gamma^5)\theta \end{bmatrix}}{(1+\gamma)(4-3\gamma^2)^2[4-2\gamma-(3-2\gamma)\theta]^2[8-4\gamma-2\gamma^2-(6-4\gamma-\gamma^2)\theta]^2} > 0,$$

where the inequality is obtained using numerical calculations.

Next, by calculating $\pi_{D1}^{TC} - \pi_{D1}^{TBC}$, we obtain the following:

$$\pi_{Di}^{TC} - \pi_{Di}^{TBC} = \frac{\gamma^2 \left[\begin{array}{l} 8\gamma - 4\gamma^2 - 2\gamma^3 + \\ (2 - 7\gamma + 3\gamma^2 + \gamma^3)\theta \end{array} \right] \left[\begin{array}{l} 64 - 32\gamma - 64\gamma^2 + 16\gamma^3 + 16\gamma^4 + 2\gamma^5 - \\ (48 - 32\gamma - 42\gamma^2 + 17\gamma^3 + 9\gamma^4 + \gamma^5)\theta \end{array} \right]}{(1+\gamma)(-4+3\gamma^2)^2[4 - 2\gamma - (3 - 2\gamma)\theta]^2[8 - 4\gamma - 2\gamma^2 - (6 - 4\gamma - \gamma^2)\theta]^2} > 0,$$

where the inequality is obtained using numerical calculations. As we obtain a similar result for firm $D2$, we obtain Proposition 2. □