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ABSTRACT

In this paper, we investigate the social impacts of strategic transfer pricing by oligopoly firms, aiming to derive regulatory implications for transfer prices. A notable finding from our model is that the negative effects on social welfare of transfer prices being set above marginal cost are pronounced when either (1) the number of competing firms is large and the product is relatively highly differentiated or (2) the number of firms is small and the product is not very differentiated. This result indicates that even when the number of firms in the industry is significant and the market is thus apparently competitive, the authorities should not overlook the possibility that setting transfer prices above marginal cost might seriously damage social welfare if the product is highly differentiated.

Keywords: Transfer pricing; Divisionalization; Product differentiation; Oligopoly; Social welfare; Management accounting

1. Introduction

The determination of internal transfer prices has been a contentious practical issue for management accounting systems in divisionalized firms. While the strategic use of transfer prices by multidivisional firms, such as multinational enterprises for the purpose of income transfer, has received attention from accounting researchers, the social influence of such strategic behavior has hardly been examined. In this paper, we investigate the social impacts of strategic transfer pricing by oligopolists, with the aim to derive regulatory implications for transfer prices. Specifically, we assume that firms that produce differentiated products face Bertrand-type price competition in the final goods market. As Fershtman and Judd (1987) and Bonanno and Vickers (1988) point out in their industrial organization studies, management wishes to divide the firm's organization vertically to dampen price competition, which leads to a retail price above marginal cost. Following their insight, we formulate one analytical model in which the firm is centralized and another in which there is decentralization into the upstream producing division and the downstream marketing division. We then compare the equilibrium outcomes of the two models.

Our models show that strategic transfer pricing under decentralization lowers not only consumer welfare but also social welfare. However, strategic transfer pricing under decentralization has no effect on social welfare when the product is either perfectly homogeneous or perfectly differentiated. A notable finding from our model is that the negative effects on social welfare of setting strategic transfer prices above marginal cost are more serious when either (1) the number of competing firms is large and the product is relatively highly differentiated, or (2) the number of firms is small (e.g., under duopoly) and the product is not very differentiated. Surprisingly, when the industry is concentrated and the product is highly differentiated, the negative effects on social welfare of strategic transfer pricing are quite mild.

Because we examine welfare effects of strategic transfer pricing, our results yield the following regulatory implications. First, even when the number of firms in an industry is significant and the market is, thus, apparently competitive, regulators should consider the possibility that transfer pricing seriously reduces social welfare if the product is highly differentiated through firm strategies such as branding. Second, even when firms' products are homogeneous because there is little differentiation, regulators should care about internal prices from the social welfare viewpoint if the number of firms is small. In these situations, even in the absence of tax rate differences among a firm's divisions, regulators should provide some specific guidelines to prevent transfer prices from substantially exceeding marginal cost due to the firm's strategic reasons. When the number of firms is large and the degree of product differentiation is low, or vice versa, strategic transfer pricing reduces social welfare very little. These results are new to the existing literature.

In transfer pricing practice, multinational firms that operate in multiple countries particularly have an incentive to set internal transfer prices for the purpose of tax evasion. Accordingly, tax authorities in advanced economies usually audit internal transfer prices within multinationals so that such strategic transfer pricing behavior does not reduce the economic welfare of the countries (Ernst and Young, 2007, 2009). In the current study,

however, we are aware that regulators also provide practical guidelines on transfer prices set for competitive strategic purposes rather than the international tax evasion purpose so as to prevent firms from abusing transfer pricing. Our focus in this paper is on such competition factors rather than on international factors for strategic transfer pricing. In reality, administrative guidelines on transfer prices set by divisionalized firms that operate mainly domestically pertain especially to those in public utility industries. Fjell and Foros (2008) present several actual cases in which regulators in European countries provide guidelines on transfer pricing for public utilities such as the electricity supply industry and the telecommunication industry. For example, European Competitive Telecommunications Association (2003: 4) states that "The SMP (Significant Market Power) operator must publish to the NRA (National Regulatory Authority) and third parties its internal transfer prices for SMP products, and its methodology for cost accounting and accounting separation...". Moreover, European Regulators Group (2006: 44) documents the following statement on electronic communications networks and services as: "Accounting separation should ensure that a vertically integrated company makes transparent its wholesale prices and its internal transfer prices especially where there is a requirement for non-discrimination".[1] Given these guidelines and reports that aim to prevent oligopolistic utility firms from setting too high or too low transfer prices, the welfare consequences resulting from the strategic transfer pricing in oligopolistic situations is a critical issue to examine.

According to the survey evidence on management accounting practices reported by Tang (1992), 46.2 percent of the transfer pricing methods among 143 Fortune 500 firms are cost based. Of these, 53.8 percent use actual or standard full production costs, and 38.5 percent use full production costs plus a markup. That only 7.7 percent use variable costs of production suggests that marginal cost pricing is rare. Mills (1988) asserts that cost-based methods are the principal basis for determining prices. Based on a survey of the largest 3,500 British companies, he reports that cost-based prices are usually modified by non-cost considerations, with competitors' prices being the most important. These surveys also indicate that firms often use internal transfer prices as a strategic device to compete with rivals under oligopoly.

In the management and accounting literature, since Hirshleifer (1956) advocated that the internal transfer price be set equal to the marginal cost in order to alleviate attendant double marginalization problems, many subsequent studies have detailed pricing forms and the ensuing distortions that can affect decentralized firms. Göx and Schiller (2007) give a comprehensive perspective of accounting research on transfer pricing that follows Hirshleifer (1956). They classify previous accounting studies on transfer prices into the following four groups in terms of the issue that they address: (1) information asymmetry among divisions (Ronen and Balachandran, 1988; Amershi and Cheng, 1990; Banker and Datar, 1992; Wagenhofer, 1994; Vaysman, 1996, 1998; Christensen and Demski, 1998; Schiller, 1999; Slof, 1999); (2) incomplete contract on divisional investment (Edlin and Reichelstein, 1995; Anctil and Dutta, 1999; Baldenius *et al.*, 1999; Baldenius, 2000; Wielenberg, 2000; Chwolka and Simons, 2003; Böckem and Schiller, 2004; Hinss *et al.*, 2005); (3) strategic interaction under oligopoly (Alles and Datar, 1998; Hughes and Kao, 1998; Göx, 2000; Narayanan and Smith,

2000; Arya and Mittendorf, 2007; Fjell and Foros, 2008; Shor and Chen, 2009); and (4) international tax issue (Schjelderup and Sørgard, 1997; Baldenius *et al.*, 2004).

According to their classification, the current study falls into the third group; it is most related to studies on the strategic benefits of decentralization-induced transfer pricing. Alles and Datar (1998) and Hughes and Kao (1998) argue that decentralization allows for tacit coordination under price competition among firms supplying goods to several markets. Göx (2000) and Narayanan and Smith (2000) demonstrate that because there are coordination benefits from setting transfer prices above marginal cost, firms thereby effectively commit to mitigate price competition. Arya and Mittendorf (2007) examine the impact of the distortions wrought by transfer pricing by firms engaged in both internal production and the external procurement of inputs. Fjell and Foros (2008) specifically focus on access prices in the telecommunications industry, in which downstream rivals must pay for access to essential upstream components controlled by a regulated firm. They point out the possibility that access price regulation, involving, e.g., accounting separation and transparency, may facilitate the regulated firm's use of transfer pricing to reduce competition. Shor and Chen (2009) show that transfer price can play a strategic role as facilitating devices that make tacit collusion sustainable when direct collusion on quantities would not be possible. However, they confine their analysis to a Cournot-type quantity competition where firms provide a homogeneous product. Most existing analytical investigations of the strategic role of transfer pricing employ a game-theoretic framework. In line with this research strand, we use a non-cooperative game as a basic setting for our model.

The above literature overview suggests that no previous research, not only in the accounting literature, but also in the economic literature, investigates how a competitive incentive for domestic transfer pricing policies under oligopoly affects social welfare. This is because existing research mainly focuses on internal performance evaluation, motivation, and the control and coordination of interests within a firm. Hence, it is worth investigating the welfare effects of setting strategic transfer prices above unit costs because increases in the selling prices of final goods brought about by the strategic behavior may decrease economic welfare. In this paper, we address this unexplored issue.

The remainder of the paper is structured as follows. In Section 2, we formalize problems for oligopolistic firms under centralized and decentralized regimes, and determine the relevant equilibrium outcomes. In Section 3, we compare consequences under these regimes and determine the social welfare effects of strategic cost-plus transfer pricing. In Section 4, we explore possible extensions of our model, followed by concluding remarks in the last section.

2. The Model

2.1. Basic Setup

In this section, we construct two models: one to represent competition among centralized firms, and the other to represent firms decentralized into an upstream producing division (division 1) and a downstream marketing division (division 2) that strategically use

internal transfer prices across divisions. Table 1 lists the variables used in the analytical model, and Figure 1 illustrates the timeline of events under each model. For both models, we assume that n firms ($n \geq 2$) that supply differentiated products engage in Bertrand-type price competition. Firm i produces brand i of the product at a variable cost of c per unit, with no fixed cost. Each firm is managed by a CEO who maximizes the total profits of the firm on behalf of the shareholders. Firm i's product quantity is denoted by q_i ($i = 1, 2, \ldots, n$).

[Table 1]

[Figure 1]

Suppose that the utility function of a representative consumer is described as:[2]

$$U(q_1, q_2, \ldots, q_n) = a \sum_{i=1}^{n} q_i - \left(b \sum_{i=1}^{n} q_i^2 + 2b\theta \sum_{i \neq j} q_i q_j \right) / 2 , \tag{1}$$

where $\theta \in [0, 1]$ represents the degree of substitution among products, and a ($> c$) and b are positive constants. For $\theta = 0$, the products are independent because of product differentiation, whereas for $\theta = 1$, the products are perfect substitutes. We assume that the utility from consuming this differentiated product is separable from the utility obtained from other products that the consumer purchases. From equation (1), we obtain the inverse demand function of product i as:

$$p_i = a - b \left(q_i + \theta \sum_{k \neq i}^{n} q_k \right), \tag{2}$$

where p_i is the retail price of firm i's product.[3] Notice that equation (2) signifies that firm i might drive up the retail price even under intense competitive pressures because of the presence of a significant number of firms, n, if θ takes a sufficiently small value. Jointly solving the inverse demand curve equations yields a solution for each quantity as a function of the prices charged by the n firms:

$$q_i = \left(-(1 + (n-2)\theta)p_i + \theta \sum_{k \neq i}^{n} p_k + (1-\theta)a \right) / ((1-\theta)(1 + \theta(n-1))b) . \tag{3}$$

Consumer surplus is stated as:

$$CS = U(q_1, q_2, \ldots, q_n) - \sum_{i=1}^{n} p_i q_i . \tag{4}$$

5

Firm i's profit is:

$$\pi_i = (p_i - c)q_i. \tag{5}$$

Therefore, total social surplus is calculated as:

$$SS = CS + \sum_{i=1}^{n} \pi_i = U(q_1, q_2, ..., q_n) - \sum_{i=1}^{n} p_i q_i + \sum_{i=1}^{n} \pi_i = U(q_1, q_2, ..., q_n) - c \sum_{i=1}^{n} q_i. \tag{6}$$

Before solving the optimization problems for the centralization and decentralization models, as a benchmark, we obtain an expression for first-best joint profits when n centralized firms form a collusion. (All proofs are in the Appendix.)

Lemma 1. *When n firms form a collusion, the optimal price and quantity are*:

$$q^{COL} = \frac{a - c}{b(2 + \theta(n-1))}, \quad p^{COL} = \frac{a + c(1 + (n-1)\theta)}{2 + (n-1)\theta}.$$

This combination yields the following total profit:

$$\Pi^{COL} = \frac{n(a-c)^2}{b(2 + (n-1)\theta)^2}.$$

In reality, collusion on retail price among firms is usually detected and punished by authorities. As we show later, the equilibrium profit under the collusion exceeds profits under both centralization and decentralization.

2.2. Centralization

Initially, we consider the case in which firms are centralized and the CEO of each firm determines only the retail price.[4] Clearly, the resulting transactions are not distorted by double marginalization. Given equation (3), firm i's profit is:

$$\pi_i = (p_i - c)q_i = (p_i - c)\left(-(1 + (n-2)\theta)p_i + \theta\sum_{k \neq i}^{n} p_k + (1-\theta)a\right) / ((1-\theta)(1+\theta(n-1))b). \tag{7}$$

Given that n firms engage in Bertrand-type price competition in this differentiated product market, the following proposition holds in equilibrium.

Proposition 1. *The equilibrium outcomes under centralization are*:

$$p_i^{\ C} = (a(1-\theta) + c(1 + (n-2)\theta))/(2 + (n-3)\theta)$$

$$q_i^{\ C} = (a-c)(1 + (n-2)\theta)/(b(1 + (n-1)\theta)(2 + (n-3)\theta))$$

$$\pi_i^{\ C} = (a-c)^2 (1-\theta)(1 + (n-2)\theta)/(b(2 + (n-3)\theta)^2 (1 + (n-1)\theta))$$

$$CS^C = (a-c)^2 n(1 + (n-2)\theta)^2 /(2b(2 + (n-3)\theta)^2 (1 + (n-1)\theta))$$

$$SS^C = (a-c)^2 n(3 + (n-4)\theta)(1 + (n-2)\theta)/(2b(2 + (n-3)\theta)^2 (1 + (n-1)\theta)),$$

where the superscript C denotes equilibrium under centralization. Therefore, p_i^C, q_i^C, π_i^C, CS^C, and SS^C respectively represent retail price, quantity, profit, consumer surplus, and social surplus under centralization.

2.3. Decentralization

We now examine firms that are decentralized into upstream and downstream divisions, with trade among divisions being governed by a transfer pricing arrangement to align different divisions, and in which the CEO aims to maximize firm-wide profit. This notion is based on the assumption of Alles and Datar (1998) and Zhao (2000) that the CEO or headquarters in an upstream division pursues the overall profit of the firm. This assumption is also consistent with the accounting practices documented by Tang (1980) and Wu and Sharp (1979), who reveal that firm-wide profit maximization and the performance evaluation of divisions are the dominant objectives of transfer pricing.

Under decentralization, a manufacturing division in the upstream (division 1) of firm i first produces brand i of the product at a variable cost per unit of c, with no fixed cost. In the first stage, each firm's CEO simultaneously determines the transfer price charged by the producing division to marketing division (division 2) and transfers its output at that price. Because the marketing manager of division 2 is charged with sale of the final product, product pricing decisions are thus delegated to the manager. Given the transfer prices set in the first stage, marketing divisions engage in Bertrand competition in the product market to maximize the division's profits in the second stage. The following proposition describes the results of the above scenario.

Proposition 2. *When firms are able to use transfer pricing strategically because of the decentralization of the organization, the equilibrium outcomes under strategic cost-plus transfer pricing are*:

$$r_i^D = \frac{a\theta^2(1-\theta)(n-1) + c(4 + 2(4n-9)\theta + (5n^2 - 25n + 28)\theta^2 + (n-3)(n^2 - 5n + 5)\theta^3)}{((1 + (n-2)\theta)(4 + 2(2n-5)\theta + (n^2 - 6n + 7)\theta^2))}$$

$$p_i^D = \frac{a(1-\theta)\big(2+(n-2)\theta\big)+c\big(2+3(n-2)\theta+\big(n^2-5n+5\big)\theta^2\big)}{4+2(2n-5)\theta+\big(n^2-6n+7\big)\theta^2}$$

$$q_i^D = \frac{(a-c)\big(2+3(n-2)\theta+\big(n^2-5n+5\big)\theta^2\big)}{b\big(1+(n-1)\theta\big)\big(4+2(2n-5)\theta+\big(n^2-6n+7\big)\theta^2\big)}$$

$$\pi_i^D = \frac{(a-c)^2(1-\theta)\big(2+(n-2)\theta\big)\big(2+3(n-2)\theta+\big(n^2-5n+5\big)\theta^2\big)}{b\big(1+(n-1)\theta\big)\big(4+2(2n-5)\theta+\big(n^2-6n+7\big)\theta^2\big)^2}$$

$$CS^D = \frac{(a-c)^2 n\big(2+3(n-2)\theta+\big(n^2-5n+5\big)\theta^2\big)^2}{2b\big(1+(n-1)\theta\big)\big(4+2(2n-5)\theta+\big(n^2-6n+7\big)\theta^2\big)^2}$$

$$SS^D = \frac{(a-c)^2 n\big(6+(5n-14)\theta+\big(n^2-7n+9\big)\theta^2\big)\big(2+3(n-2)\theta+\big(n^2-5n+5\big)\theta^2\big)}{2b\big(1+(n-1)\theta\big)\big(4+2(2n-5)\theta+\big(n^2-6n+7\big)\theta^2\big)^2},$$

where the superscript D denotes equilibrium outcomes under decentralization.

3. Comparative Statics and Welfare Analysis
3.1. Differences between Equilibrium Outcomes

Given the propositions already derived, we compare the economic outcomes under both regimes.[5] Initially, the preceding propositions yield the following corollaries.

Corollary 1. *The inequalities with respect to profits, $\Pi^{COL} \geq n\pi_i^D \geq n\pi_i^C$, hold, indicating that the joint profits of firms are higher in order of collusion, decentralization and centralization.*

Corollary 2. *The inequalities with respect to prices, $p^{COL} \geq p_i^D \geq p_i^C$, hold, meaning that the equilibrium retail price is higher in order of collusion, decentralization and centralization.*

The intuition behind Corollaries 1 and 2 is that firms can jointly drive up the retail price by forming a collusion, thus, completely eliminating the strategic interactions among oligopolistic firms. Because this collusion is expected to reduce consumer welfare, collusion on price, such as cartel formation among firms, is usually prohibited by regulators. An important implication from the corollaries that we should notice is that strategic transfer pricing under decentralization functions as a "partial collusion" to drive up the retail price by alleviating the retail price competition, because Corollaries 1 and 2 indicate that both the profit per firm and the retail price under decentralization take values between those under collusion and centralization (Bonanno and Vickers, 1988; Shor and Chen, 2009). We later use this notion that equilibrium transfer pricing under decentralization may be interpreted as a partial collusion to provide an intuitive explanation for central analytical results.

To clarify our comparison of the outcomes under centralization and decentralization, we summarize the differences in the equilibrium outcomes in the following proposition.

Proposition 3. *The calculated differences in the equilibrium variables and functions between decentralization and centralization are as follows*:

$$\Delta r_i = r_i^D - c = \frac{(a-c)(n-1)(1-\theta)\theta^2}{\left(1+(n-2)\theta\right)\left(4+2(2n-5)\theta+\left(n^2-6n+7\right)\theta^2\right)}$$

$$\Delta p_i = \frac{(a-c)(n-1)(1-\theta)\theta^2}{\left(2+(n-3)\theta\right)\left(4+2(2n-5)\theta+\left(n^2-6n+7\right)\theta^2\right)}$$

$$\Delta q_i = -\frac{(a-c)(n-1)(1-\theta)\theta^2}{b\left(2+(n-3)\theta\right)\left(1+(n-1)\theta\right)\left(4+2(2n-5)\theta+\left(n^2-6n+7\right)\theta^2\right)}$$

$$\Delta \pi_i = \frac{(a-c)^2(n-1)^2\theta^3(1-\theta)\left(4+(4n-11)\theta+(n-2)(n-4)\theta^2\right)}{b\left(1+(n-1)\theta\right)\left(2+(n-3)\theta\right)^2\left(4+2(2n-5)\theta+\left(n^2-6n+7\right)\theta^2\right)^2}$$

$$\Delta CS = -\frac{(a-c)^2 n(n-1)\theta^2(1-\theta)\left(8+4(4n-9)\theta+\left(55-49n+10n^2\right)\theta^2+\left(-29+39n-16n^2+2n^3\right)\theta^3\right)}{2b\left(1+(n-1)\theta\right)\left(2+(n-3)\theta\right)^2\left(4+2(2n-5)\theta+\left(n^2-6n+7\right)\theta^2\right)^2}$$

$$\Delta SS = -\frac{(a-c)^2 n(n-1)\theta^2(1-\theta)^2\left(8+4(2n-5)\theta+\left(13-11n+2n^2\right)\theta^2\right)}{2b\left(1+(n-1)\theta\right)\left(2+(n-3)\theta\right)^2\left(4+2(2n-5)\theta+\left(n^2-6n+7\right)\theta^2\right)^2},$$

where Δ is the difference operator between decentralization and centralization. ΔCS and ΔSS respectively are differences in the consumer surplus and the social surplus aggregated across brands of the product. In addition, Δr_i is defined as $r_i^D - c$ because the centralized regime is equivalent to a decentralized regime in which the transfer price is predetermined as being equal to marginal cost, c, as discussed earlier.

Note that throughout this paper, net social surplus is equal to gross social surplus because the firms incur no fixed cost. Given Proposition 3, we can examine the impacts of strategic cost-plus transfer pricing on welfare. The next corollary follows directly from Proposition 3.

Corollary 3. *When products are either perfect substitutes ($\theta = 1$) or perfectly differentiated ($\theta = 0$), all firms equate their transfer prices, r_i, to marginal cost, c, even under decentralization.*

When the product is perfectly differentiated across firms ($\theta = 0$), each firm can behave as a monopolist. Corollary 3 indicates that firms set their transfer prices equal to marginal cost so that the supply quantities are not reduced because of double marginalization. At the other extreme, if there is no product differentiation ($\theta = 1$), firms cannot set a price above the marginal cost because of perfect Bertrand competition. In this case, firms must set both their retail prices and transfer prices equal to marginal cost. Therefore, note that the economic intuition behind Corollary 3 differs completely for the two extreme cases of $\theta = 1$ and $\theta = 0$.

The next corollary relates to the difference in transfer prices.

Corollary 4. *Δr_i is maximized at $\theta = \theta_r$. Moreover, the function for Δr_i is single peaked at θ_r, with $0 < \theta_r < 1$.*

Corollary 4 indicates that under decentralization, the strategic transfer price deviates most from marginal cost, *c*, when there is an intermediate level of product differentiation; i.e., when θ is around θ_r. The next corollaries also follow from Proposition 3.

Corollary 5. *The inequalities, $\Delta r_i \geq 0$ and $\Delta p_i \geq 0$ hold, meaning that strategic transfer pricing under decentralization raises both the transfer price and the retail price.*

Corollary 6. *The inequality, $\Delta q_i \leq 0$ holds, indicating that strategic transfer pricing under decentralization reduces supply quantity.*

Note that neither cost factors nor tax avoidance but only strategic motivations lead firms to inflate the equilibrium transfer price in our model. This is consistent with the empirical findings of Mills (1988). At first glance, we might conjecture that firms are unwilling to set transfer prices above marginal cost because of the double marginalization problem, but this is not the case. Facing strong price competition, firms are motivated to set retail prices close to the first-best retail price, which can be achieved by collusion, as suggested by Corollary 2. Our result in the presence of multiple competing firms is consistent with the results of the duopoly model of Bonanno and Vickers (1988).

3.2. Welfare Consequences

The main purpose of this study is to obtain the welfare implications of our results. Under the following extreme situations, strategic transfer pricing does not affect welfare.

Corollary 7. *When the product is either perfectly homogeneous ($\theta = 1$) or perfectly differentiated ($\theta = 0$), the consumer surplus and the social surplus are the same under centralization and decentralization; i.e., $\Delta CS = 0$ and $\Delta SS = 0$.*

The next corollary states that if the product is moderately differentiated, strategic transfer pricing reduces consumer welfare.

Corollary 8. *The inequality, $\Delta CS \leq 0$ always holds, meaning that the consumer surplus is weakly lower when firms use strategic transfer pricing under decentralization than under centralization.*

Corollary 8 is intuitive because double marginalization drives up the retail price and reduces supply. The next corollary states that strategic transfer pricing lowers social welfare if the product is moderately differentiated.

Corollary 9. *The inequality, $\Delta SS \leq 0$ always holds, indicating that the social surplus is weakly lower when firms use strategic transfer pricing under decentralization than under centralization.*

We now examine the conditions under which ΔSS is substantially negative because of firms' use of transfer prices under decentralization. Because the functional form of ΔSS is complicated, it is difficult to find the values of θ and n that minimize the function. Moreover, one cannot differentiate ΔSS with respect to n because n is a positive integer whereas θ is a continuous variable. Fortunately, however, the combination of (n, θ) that minimizes ΔSS is independent of a, b, and c, because these three exogenous variables are multiplicatively separable in the ΔSS function, as indicated by Proposition 3. Therefore, one can numerically derive the combinations of n and θ that minimize ΔSS when one of the two endogenous variables is held constant. For this, we first fix the number of competing firms, n, at a constant positive integer, and, then, find the θ^* that minimizes ΔSS. Similarly, we fix product homogeneity, θ, and find the n^* that minimizes ΔSS. The results are summarized as the next remark.

Remark 1. *The values of θ and n that lie at the bottom of the curved surface in the three-dimensional graph where ΔSS is drawn against the axes of θ and n tend to be negatively correlated. Namely, the negative effects on social welfare of transfer prices being set above marginal cost are pronounced when either (1) the number of competing firms is large and the product is relatively highly differentiated or (2) the number of firms is small and the product is not very differentiated.*

Using the expression for ΔSS from Proposition 3 yields the computed combinations of n and θ presented in Figure 2. The trajectory of the combinations of n and θ^*, where the θ^* minimizes ΔSS when the number of firms, n, is fixed, is shown in Panel A of the figure. On the other hand, the trajectory of the combinations of θ and n^*, where the n^* minimizes ΔSS when θ is a fixed constant, is shown in Panel B.

[Figure 2]

Figure 3 illustrates the curved surface of ΔSS when both n and θ vary.[6] This shows that the values of n and θ that track the bottom of the curved surface are negatively correlated. Therefore, the figure suggests that the negative effects on social welfare of setting strategic transfer prices above marginal cost are more serious when either (1) a small number of firms provide relatively homogeneous products or (2) a large number of firms sell relatively highly differentiated products. This finding has a practical implication for regulators. First, even when the number of firms in an industry is quite large and the market is thus apparently competitive, the authorities should be aware of the possibility that cost-plus transfer pricing will harm social welfare if firm strategies such as brand establishment lead to highly

differentiated products. Second, even when there is little product differentiation, the authorities should consider the potential social welfare effects of internal pricing when the number of firms is small. In these circumstances, in particular, the authorities should provide specific guidelines to ensure that transfer prices are not substantially above marginal cost.

[Figure 3]

3.3. Economic Implication

Given the central finding in this study (Remark 1), we explore the economic rationale for it. Several previous studies in the industrial economic literature investigate strategic vertical separation of organization under product differentiation (e.g., Bonanno and Vickers, 1988; Gal-Or, 1990, 1991; Cyrenne, 1994). Although their focus is not the internal transfer price but the wholesale price between a manufacturer and a retailer, we can use their insights because we may interpret the wholesale price as the transfer price between divisions within a decentralized firm. As Cyrenne (1994) demonstrates, duopolistic manufacturers in the decision to raise their price to retailers face two conflicting forces under product differentiation. If they raise their wholesale price they exacerbate the double marginalization problem. Namely, sales of the product are reduced below the desired level by an additional markup by the marketing division if the division has some market power. However, a firm also obtains a strategic benefit from having other firms raise their prices in response because the price is the strategic complement variable. The relative strengths of these forces depend on the degree of product differentiation. When the products are poor substitutes, the adverse effect of the double marginalization surpasses the benefit from having competitors also raise their price. When the products are relatively close substitutes, the double marginalization problem is more than offset by the strategic benefit obtained from having both the transfer price and the retail price of rival firms rise.

In addition to the above insight in Cyrenne (1994), our model demonstrates that firms become more subject to Bertrand competition pressures than to the strategic benefit of decentralization as n increases under a fixed value of θ. Figure 4 plots the equilibrium transfer price under decentralization based on Proposition 2, where Panel A plots the price when n is small and Panel B plots the price when n is large. As illustrated in the figure, the interval where the pressures prevent firms from raising transfer price, r_i, is longer in Panel B than in Panel A, because Bertrand competitive pressures grow as n increases. Accordingly, the degree of product differentiation, θ_r, that gives the peak of the transfer price moves leftward as shown in Panel B of the figure.[7] This is because it becomes difficult for one of the firms to induce price reaction functions of other firms to move outward through decentralization in order to sustain higher retail price as the number of competitors grows. Namely, the strategic benefit is gradually overwhelmed by competitive pressures as n increases.

[Figure 4]

12

Next, we examine how the retail price, p, rather than the transfer price reacts to n and θ. Figure 5 draws equilibrium retail prices under collusion, centralization, and decentralization based on Lemma 1 and Propositions 1 and 2, respectively. In the figure, the prices are drawn when n is relatively small (Panel A), when n is relatively large (Panel B), and when n diverges to positive infinity (Panel C). In an extreme situation where the number of firms, n, diverges to infinity, all the prices under collusion, centralization, and decentralization converge to the horizontal line, which equals the marginal cost c, except when $\theta = 0$ as illustrated in Panel C of Figure 5. Therefore, if the product is not perfectly differentiated, it gradually becomes difficult for firms to raise the retail price through the partial collusion resulting from strategic decentralization as n increases. Moreover, as can be seen from the three panels of Figure 5, because θ, where the curvature of the graphs of the retail price is the largest, tends to move leftward as n increases, then θ_p, which maximizes the deviation between p^D and p^C, also moves leftward according to n.[8] Therefore, when n is small, social welfare particularly decreases due to a retail price rise if θ is relatively large. By contrast, when n is large, the decrease of social welfare is serious if θ is small.

[Figure 5]

The above intuitive explanations lead us to make a summary of the results.
(1) When n is relatively small:

If θ is relatively large (i.e., differentiated only slightly), because the strategic benefit for transfer pricing dominates the adverse effect of double marginalization, firms particularly raise the transfer price, leading to serious deterioration of social welfare. Conversely, if θ is low, each firm will rather alleviate strategic transfer pricing so that sales of the product are not reduced below the desired level by an additional markup at the downstream division level, because the marketing division of each firm has strong market power due to product differentiation. As a consequence, the adverse effect on social welfare becomes less problematical.
(2) When n is relatively large:

If θ is small, the margin for firms to raise the retail price increases, because product differentiation relieves firms of competition pressures, leading to a serious decrease in social welfare. By contrast, if θ takes a high value, fierce price competition pressure prevents firms from raising the transfer price and the retail price, because the margin for firms to drive up the retail price decreases as a consequence of the weak market power of each firm.

This is the fundamental reason why θ and n that seriously damage social welfare have inverse correlation as shown in Remark 1, namely, an inverse relationship between n and θ that tracks the bottom of the curve in Figure 3 generates.

4. Discussion and Extension
4.1. Tax Evasion
Our central issue throughout this study is how social welfare is influenced by strategic

transfer pricing behavior of oligopolistic firms that supply differentiated product. However, other important dimensions of social welfare such as tax issues have not been explicitly treated in our model. In this section, we discuss limitations of our model and explore the possibility of further extensions.

As referred earlier, a major practical motivation for the choice of transfer pricing methods is taxes. Recently, many countries have released special legislation and documentation rules for international transfer prices. For example, in the United States, Section 482 of the Internal Revenue Code requires that transfer prices be set as arm's length prices, specifying that the price of comparable third-party transactions must be used as the transfer price.

Although we take oligopolistic firms in utility industries as a typical empirical example for our model, it should be noted that we may presume multinational firms in a more general industry as an alternative example for the model. Suppose that oligopolistic multinationals operate in the following two countries: upstream producing divisions of them produce the differentiated products in a host country, and downstream marketing divisions sell the product to end-consumers in the home country. Moreover, we assume that the corporate tax rates in the two countries are the same, meaning that the firms have no incentive of tax-induced transfer pricing. Under these circumstances, such multinationals will behave similarly to our model, namely, they will have strategic transfer pricing incentive even in the absence of tax differences.

4.2. Internal Factors for Strategic Transfer Pricing

In our model, strategic considerations are a main factor for the use of full cost-based transfer pricing. However, another potential driver of domestic transfer-pricing policies is the provision of an investment incentive in divisionalized firms. The accounting literature has analyzed the incentives provided by a transfer pricing mechanism for undertaking specific divisional investment within firms (e.g., Edlin and Reichelstein, 1995; Anctil and Dutta, 1999; Baldenius, 2000; Hinss *et al.*, 2005). Overall, the transfer pricing problem arises when divisions can make upfront specific investments that enhance the value of internal trade but have limited value for the divisions' business with outside partners. This problem is known as the "hold-up" problem.

Although this type of investment has not been considered in our model, we should note that the internal investment made by subordinate divisions in a decentralized firm, as well as the pricing strategy to external markets, also creates a strategic transfer-pricing incentive even in the absence of international tax difference.

4.3. Observability and Commitment

Our preceding analysis rests implicitly on the assumption that the managers of firms simultaneously observe their competitors' transfer prices before deciding on their pricing strategies for the final product. With this assumption, transfer pricing serves as a commitment device vis-à-vis the competitor. However, it is well known that strategic transfer pricing has no strategic effect if firms cannot commit to publicly observable transfer prices above

marginal costs, because the division managers cannot react to something that they do not observe. Without the strategic effect, the optimal transfer price equals the marginal cost of the intermediate product. However, Narayanan and Smith (2000) demonstrate that an international tax-rate difference may work as the signal that transfer prices deviate from marginal costs.

An appropriate practical example for the credible signaling of a certain transfer pricing policy is the commitment to a particular cost accounting system (Göx, 2000). Choosing an accounting system is typically a long-term commitment because its introduction requires substantial investments associated with the installation of the system. Hence, such a cost accounting system may work as a signaling device and provide solution for the unobservability of transfer prices. Because our model focuses on strategic interactions in a Bertrand fashion among oligopoly firms, cost-plus transfer pricing automatically results. However, as Tang (1992) suggests, several companies adopt actual or standard variable cost of production for a transfer pricing method. Therefore, we might incorporate the choice of a cost accounting system into our model if we extend the present model to consider the possibility that transfer prices are unobservable.

4.4. Organization Regimes

Finally, although we have proved that decentralization of the organization and the strategic transfer pricing is the weakly dominant strategy (Corollary 1), coexistence of different organization regimes may result if the strategic variable for the firms is not price.[9] Jansen (2003) demonstrates that coexistence of decentralization and centralization emerges, namely, vertical separation is chosen by some upstream firms, while vertical integration is chosen by others in the equilibrium of symmetric firms when more than two vertical oligopolists who supply close substitutes compete in a Cournot fashion. However, his model is based on a Cournot-type quantity competition instead of Bertrand-type competition. It is of interest to investigate how our welfare implications change by modifying the competition from Bertrand-type to Cournot-type in our model, because such an issue is unaddressed in the literature.

5. Concluding Remarks

Many papers have addressed the transfer pricing problem, particularly in the accounting and management literature. In this paper, we investigated the social welfare effects of transfer pricing by divisionalized firms, which have rarely been addressed. Our analytical model demonstrates that strategic transfer pricing reduces not only consumer welfare but also social welfare when products are moderately differentiated across competing firms. In particular, social welfare effects are particularly adverse when either (1) the number of firms is large and the product is relatively highly differentiated; or (2) the number of firms is small and the product is not very differentiated. Strategic transfer pricing hardly affects social welfare, not only when the number of competing firms is quite large and products are homogeneous, but also when the industry is concentrated and the product is highly

differentiated. These counter-intuitive results are new to both the accounting literature and the economics literature.

Although tax authorities usually monitor multinational enterprises, our results indicate that domestic companies whose objective is not tax avoidance have sufficient strategic incentives to set transfer prices above unit production costs, which adversely affects equilibrium social welfare. To summarize, under the situations described by (1) and (2) above, our results imply that authorities should provide practical transfer pricing guidelines not only to multinationals but also to general divisionalized companies, even if they do not transact intermediate products across different tax jurisdictions. Indeed, we presented several actual cases that regulators provide specific guidelines on transfer prices of public utility services in EU countries. Because firms in public utility industries are often characterized by oligopoly and by slight differentiation of product or service, we expect that they have strategic incentive for transfer pricing as an exact empirical example described by our model. Moreover, we expect that its welfare impact is significant because the services are usually necessities for both consumers and firms. For these reasons, regulators are particularly concerned with transfer prices within the utility industries referred in this paper.

Appendix
Proof of Lemma 1

The expression for joint profits aggregated across n firms is:

$$\Pi^{COL} = \sum_{k=1}^{n} \pi_k = \sum_{k=1}^{n} (p_i - c) q_i = \sum_{k=1}^{n} \left(a - b \left(q_k + \theta \sum_{j \neq k}^{n} q_j \right) - c \right) q_k .$$

Note that maximization of Π^{COL} with respect to $\{q_1, q_2, \ldots, q_n\}$ is equivalent to maximization of Π^{COL} with respect to $\{p_1, p_2, \ldots, p_n\}$ after replacing $\{q_1, q_2, \ldots, q_n\}$ with $\{p_1, p_2, \ldots, p_n\}$ by using the demand function represented by equation (2). Hence, we maximize Π^{COL} with respect to the quantities:

$$\frac{\partial \Pi^{COL}}{\partial q_i} = (a - c) - 2bq_i - b\theta \sum_{k \neq i}^{n} q_k = 0, \tag{A1}$$

$$\frac{\partial^2 \Pi^{COL}}{\partial q_i^2} = -2b < 0 . \tag{A2}$$

Solving equation (A1) for q_i ($i = 1, 2, \ldots, n$) simultaneously yields:

$$q^{COL} = \frac{a - c}{b(2 + \theta(n-1))} .$$

Substituting this quantity into the inverse demand and profit functions yields the equilibrium price and optimized profit presented in the lemma. □

Proof of Proposition 1

16

Firm i's profit under centralization is:

$$\pi_i = (p_i - c)\left(-(1+(n-2)\theta)p_i + \theta\sum_{k\neq i}^{n} p_k + (1-\theta)a\right) / ((1-\theta)(1+\theta(n-1))b). \tag{A3}$$

The first- and second-order derivative of (A3) with respect to p_i is:

$$\frac{\partial \pi_i}{\partial p_i} = \frac{a+c-a\theta-2c\theta+cn\theta-(2+(2n-4)\theta)p_i + \theta\sum_{k\neq i}^{n} p_k}{b(1-\theta)(1+(n-1)\theta)} = 0, \tag{A4}$$

$$\frac{\partial^2 \pi_i}{\partial p_i^2} = -\frac{2+2(n-2)\theta}{b(1-\theta)(1+(n-1)\theta)} < 0. \tag{A5}$$

Because inequality (A5) suggests that the second-order derivative is negative, we may derive the solution of retail price that maximizes firm i's profit by solving equation (A4). Simultaneously solving the first-order conditions for firms 1 to n yields the equilibrium price:

$$p_i^C = \frac{(1-\theta)a + c(1+(n-2)\theta)}{2+(n-3)\theta}. \tag{A6}$$

Replacing the price in equation (3) with (A6) yields:

$$q_i^C = (a-c)(1+(n-2)\theta) / (b(1+(n-1)\theta)(2+(n-3)\theta)). \tag{A7}$$

Evaluating (A3) at the equilibrium price and quantity given by equations (A6) and (A7) yields firm i's optimal profit:

$$\pi_i^C = (a-c)^2(1-\theta)(1+(n-2)\theta) / (b(2+(n-3)\theta)^2(1+(n-1)\theta)). \tag{A8}$$

Substituting equations (A6) and (A7) into equation (4) yields CS^C, and into equation (6) yields SS^C, respectively. □

Proof of Proposition 2

To determine the equilibrium under decentralization, we solve the game theoretic model backwards. For a given transfer price, r_i, the marketing division of firm i will choose the retail price, p_i, to maximize its divisional profit in the second stage. Given equation (3), the profit of division 2 in firm i is:

$$\pi_{i2} = (p_i - r_i)q_i = (p_i - r_i)\left(-(1+(n-2)\theta)p_i + \theta\sum_{k\neq i}^{n} p_k + (1-\theta)a\right) / ((1-\theta)(1+\theta(n-1))b).$$

Maximizing π_{i2} with respect to p_i yields firm i's division 2 price reaction function:

$$\frac{\partial \pi_{i2}}{\partial p_i} = \frac{(1-\theta)a - (2+(2n-4)\theta)p_i + (1+(n-2)\theta)r_i + \theta\sum_{k\neq i}^{n} p_k}{b(1-\theta)(1+(n-1)\theta)} = 0, \tag{A9}$$

$$\frac{\partial^2 \pi_{i2}}{\partial p_i^2} = -\frac{2 + 2(n-2)\theta}{b(1-\theta)(1+(n-1)\theta)} < 0.$$
(A10)

Because the second-order condition is met according to inequality (A10), profit for each firm is maximized by solving equation (A9) for p_i ($i = 1, 2, \ldots, n$) as follows:

$$p_i = \left(a(1-\theta)(2+(2n-3)\theta) + (1+(n-2)\theta)\left(\theta \sum_{k \neq i}^{n} r_k + (2+(n-2)\theta)r_i \right) \right) / (2+(2n-3)\theta)(2+(n-3)\theta).$$
(A11)

Given (A11), the CEO of firm i maximizes the firm-wide profit function, $\pi_i = (p_i - c)q_i$. To solve the problem, we first substitute (A11) into equation (3), rewriting q_i as a function of $\{r_1, r_2, \ldots, r_n\}$ rather than $\{p_1, p_2, \ldots, p_n\}$. Then, we substitute this demand function and the price given by equation (A11) into $\pi_i = (p_i - c)q_i$, thus maximizing π_i with respect to r_i. The first- and second-order derivatives are:

$$\frac{\partial \pi_i}{\partial r_i}$$
$$= ((2 + 5(n-2)\theta + (4n^2 - 17n + 17)\theta^2 + (n^3 - 7n^2 + 15n - 10)\theta^3)$$
$$\left((2+(2n-3)\theta)(-a(1-\theta) + c((n-3)\theta+2)) - (2+(3n-7)\theta + (n^2-5n+6)\theta^2)r_i - \theta(1+(n-2)\theta)\sum_{i=1}^{n} r_i \right)$$
$$+ (2+(n-3)\theta)(1+(n-2)\theta)(2+(n-2)\theta)(2+(2n-3)\theta)$$
(A12)
$$\left((1-\theta)a + \theta \sum_{j=1}^{n} \frac{a(1-\theta)(2+(2n-3)\theta) + (1+(n-2)\theta)\left((2+(n-3)\theta)r_j + \theta \sum_{k=1}^{n} r_k \right)}{(2+(n-3)\theta)(2+(2n-3)\theta)} \right.$$
$$\left. + \frac{(-1+\theta-n\theta)\left(-a(-1+\theta)(2+(2n-3)\theta) + (1+(n-2)\theta)(2+(n-3)\theta)r_i + \theta \sum_{i=1}^{n} r_i \right)}{(2+(n-3)\theta)(2+(2n-3)\theta)} \right)) /$$
$$\left(b(1-\theta)(2+(n-3)\theta)^2 (1+(n-1)\theta)(2+(2n-3)\theta)^2 \right)$$
$$= 0$$

$$\frac{\partial^2 \pi_i}{\partial r_i^2} = -\frac{2(1+(n-2)\theta)^2(2+(n-2)\theta)(2+3(n-2)\theta + (n^2-5n+5)\theta^2)}{b(1-\theta)(2+(n-3)\theta)^2(1+(n-1)\theta)(2+(2n-3)\theta)^2} < 0.$$
(A13)

Because the second-order derivative is negative, equation (A12) signifies firm i's optimal reaction function that maximizes π_i. Simultaneously solving equation (A12) set equal to 0 for $\{r_1, r_2, \ldots, r_n\}$ yields the equilibrium transfer price:

$$r_i^D = \frac{a\theta^2(1-\theta)(n-1) + c(4 + 2(4n-9)\theta + (5n^2-25n+28)\theta^2 + (n-3)(n^2-5n+5)\theta^3)}{((1+(n-2)\theta)(4+2(2n-5)\theta + (n^2-6n+7)\theta^2))}.$$
(A14)

Substituting (A14) into (A11) yields the retail price:

$$p_i^D = \frac{a(1-\theta)(2+(n-2)\theta) + c(2+3(n-2)\theta + (n^2-5n+5)\theta^2)}{4 + 2(2n-5)\theta + (n^2-6n+7)\theta^2}.$$
(A15)

By substituting (A15) into equation (3), we obtain the equilibrium quantity, q_i^D. Using the equilibrium prices and quantity yields the expression for equilibrium profit given in Proposition 2. Substituting equations (A15) and q_i^D into equation (4) yields CS^D, and into

equation (6) yields SS^D, respectively. □

Proof of Corollary 1

The difference in joint profits between firms operating under collusion and those operating under decentralization is:

$$\Pi^{COL} - n\pi_i^D = \frac{n(a-c)^2(n-1)^2\theta^3(1+(n-2)\theta)(4+(4n-9)\theta+(n^2-5n+5)\theta^2)}{b(1+(n-1)\theta)(2+(n-1)\theta)^2(4+2(2n-5)\theta+(7-6n+n^2)\theta^2)^2}.$$

Having defined $\gamma 1(n,\theta)=4+(4n-9)\theta+(n^2-5n+5)\theta^2$, the following two inequalities are satisfied because $0 \le \theta \le 1$:

$$\gamma 1(2,\theta)=4-\theta-\theta^2=-(\theta+1/2)^2+5/4>0,\tag{A16}$$

$$\gamma 1(n+1,\theta)-\gamma 1(n,\theta)=2\theta(2+(n-2)\theta)\ge 0.\tag{A17}$$

Based on mathematical induction, equations (A16) and (A17) indicate that $\gamma 1(n,\theta) > 0$ when $n \ge 2$. Because $\gamma 1(n,\theta) > 0$ and

$$\frac{n(a-c)^2(n-1)^2\theta^3(1+(n-2)\theta)}{b(1+(n-1)\theta)(2+(n-1)\theta)^2(4+2(2n-5)\theta+(7-6n+n^2)\theta^2)^2}\ge 0,\text{ it follows that }\Pi^{COL}\ge n\pi_i^D.$$

Next, the difference between decentralization and centralization is:

$$\pi_i^D-\pi_i^C=\frac{(a-c)^2(n-1)^2\theta^3(1-\theta)(4+(4n-11)\theta+(n-2)(n-4)\theta^2)}{b(1+(n-1)\theta)(2+(n-3)\theta)^2(4+2(2n-5)\theta+(n^2-6n+7)\theta^2)^2}.\tag{A18}$$

Because $0 \le \theta \le 1$ and $n \ge 2$, we may confirm that equation (A18) is positive. Therefore, the inequalities, $\Pi^{COL}\ge n\pi_i^D\ge n\pi_i^C$, hold. □

Proof of Corollary 2

The difference between the retail price under collusion and that under decentralization is:

$$p^{COL}-p_i^D=\frac{(a-c)(n-1)\theta^2(1+(n-2)\theta)}{(2+(n-1)\theta)(4+2(2n-5)\theta+(7-6n+n^2)\theta^2)}.$$

Having defined $\gamma 2(n,\theta)=4+2(2n-5)\theta+(n^2-6n+7)\theta^2$, the following two inequalities are satisfied because $0 \le \theta \le 1$:

$$\gamma 2(2,\theta)=4-2\theta-\theta^2=-(\theta+1)^2+5>0,\tag{A19}$$

$$\gamma 2(n+1,\theta)-\gamma 2(n,\theta)=\theta(4+(2n-5)\theta)\ge 0.\tag{A20}$$

Based on mathematical induction, equations (A19) and (A20) indicate that $\gamma 2(n,\theta) > 0$ because $n \ge 2$. Given, in addition, that $(a-c)(n-1)\theta^2(1+(n-2)\theta)/(2+(n-1)\theta)\ge 0$, then

19

$p^{COL} \geq p_i^{D}$. As shown subsequently for Corollary 5, $p_i^{D} - p_i^{C} \geq 0$. Hence, $p^{COL} \geq p_i^{D} \geq p_i^{C}$. □

Proof of Proposition 3

Each difference can be calculated by subtracting the corresponding outcome in Proposition 1 from that in Proposition 2. Moreover, the difference in the total consumer surplus, aggregated across brands, between two regimes is:

$$\Delta CS = CS^{D} - CS^{C}.$$

Furthermore, the total social surplus is:

$$\Delta SS = \Delta CS + \sum_{i=1}^{n} \Delta \pi_i .$$

These calculations yield the difference for each variable presented in the proposition. □

Proof of Corollary 3

Evaluating Δr_i in Proposition 3 at $\theta = 1$ or $\theta = 0$ yields this corollary. □

Proof of Corollary 4

The derivative of Δr_i with respect to θ is:

$$\frac{\partial \Delta r_i}{\partial \theta} = \frac{(a-c)(n-1)\left(8 + (8n-30)\theta - 4(4n-9)\theta^2 - \left(13 - 5n - 3n^2 + n^3\right)\theta^3\right)}{(1+(n-2)\theta)^2\left(4 + 2(2n-5)\theta + \left(7 - 6n + n^2\right)\theta^2\right)^2}. \tag{A21}$$

Let $\gamma 3(n,\theta) = 8 + (8n-30)\theta - 4(4n-9)\theta^2 - \left(13 - 5n - 3n^2 + n^3\right)\theta^3$. Because

$\gamma 3(n,0) = 8$, $\gamma 3(n,1) = -(n-1)^3 < 0$, it follows that $\gamma 3(n, \theta) = 0$ has at least one solution in the interval $0 < \theta < 1$. Solving $\gamma 3(n, \theta) = 0$ for θ shows that two of the solutions are imaginary and the remaining one is real.[10] Therefore, Δr_i has a unique extremal in the interval of $0 < \theta < 1$, which implies that Δr_i is single peaked at θ_r and maximized. □

Proof of Corollary 5

$$\Delta r_i = \frac{(a-c)(n-1)(1-\theta)\theta^2}{(1+(n-2)\theta)\left(4 + 2(2n-5)\theta + \left(n^2 - 6n + 7\right)\theta^2\right)}$$

Because $n \geq 2$, $(a-c)(n-1)(1-\theta)\theta^2 /(1+(n-2)\theta) \geq 0$ holds. Moreover, as shown to prove

Corollary 2, $\gamma 2(n,\theta) = 4 + 2(2n-5)\theta + \left(n^2 - 6n + 7\right)\theta^2 > 0$. Hence, $\Delta r_i \geq 0$. Proposition 3

suggests that $\Delta p_i = \Delta r_i(1+(n-2)\theta)/(2+(n-3)\theta)$. Given that $n \geq 2$ and $0 \leq \theta \leq 1$, it follows

that $(1+(n-2)\theta)/(2+(n-3)\theta) \geq 0$. Therefore, the sign of Δp_i is the same as that of Δr_i, i.e.,

positive or zero. □

Proof of Corollary 6

Because Proposition 3 suggests that $\Delta q_i = -\Delta p_i / b(1 + (n-1)\theta)$ and Corollary 5 shows that $\Delta p_i \geq 0$, the inequality, $\Delta q_i \leq 0$ holds. □

Proof of Corollary 7

Evaluating ΔCS and ΔSS in Proposition 3 at $\theta = 1$ or $\theta = 0$ yields this corollary. □

Proof of Corollary 8

Having defined

$$\gamma 4(n, \theta) = 8 + 4(4n - 9)\theta + (55 - 49n + 10n^2)\theta^2 + (-29 + 39n - 16n^2 + 2n^3)\theta^3,$$ the following

two inequalities are satisfied because $0 \leq \theta \leq 1$:

$$\gamma 4(2, \theta) = 8 - 4\theta - 3\theta^2 + \theta^3 \geq 2, \tag{A22}$$

$$\gamma 4(n+1, \theta) - \gamma 4(n, \theta) = \theta(16 + (20n - 39)\theta + (6n^2 - 26n + 25)\theta^2) \geq 0. \tag{A23}$$

Based on mathematical induction, equations (A22) and (A23) indicate that $\gamma 4(n,\theta) > 0$ because $n \geq 2$. Given, in addition, that

$$-\frac{(a-c)^2 n(n-1)\theta^2(1-\theta)}{2b(1 + (n-1)\theta)(2 + (n-3)\theta)^2(4 + 2(2n-5)\theta + (n^2 - 6n + 7)\theta^2)^2} \leq 0,$$ it follows that ΔCS in

Proposition 3 is negative or zero. □

Proof of Corollary 9

Denote $f(n, \theta)$ and $g(n, \theta)$ as:

$$f(n,\theta) = -\frac{(a-c)^2 n(n-1)\theta^2(1-\theta)^2}{2b(1 + (n-1)\theta)(2 + (n-3)\theta)^2(4 + 2(2n-5)\theta + (n^2 - 6n + 7)\theta^2)^2}$$

$$g(n,\theta) = 8 + 4(2n-5)\theta + (13 - 11n + 2n^2)\theta^2.$$

Hence, $\Delta SS = f(n, \theta) \cdot g(n, \theta)$. The following two inequalities are satisfied because $0 \leq \theta \leq 1$:

$$g(2, \theta) = 8 - 4\theta - \theta^2 = -(\theta + 2)^2 + 12 > 0, \tag{A24}$$

$$g(n+1, \theta) - g(n, \theta) = \theta(8 + (4n - 9)\theta) \geq 0. \tag{A25}$$

Based on mathematical induction, (A24) and (A25) indicate that $g(n,\theta) > 0$ because $n \geq 2$. Given, in addition, $f(n, \theta) \leq 0$, the corollary is proven. □

Notes

1. Regulators in advanced economies other than Europe also present such guidelines for utility industries. In the United States, Public Utility Commission of Texas (1998) notes that: "[T]here is a strong likelihood that a utility will favor its affiliates where these affiliates are providing services in competition with other, non-affiliated entities … there is a strong incentive for regulated utilities or their holding companies to subsidize their competitive activity with revenues or intangible benefits derived from their regulated monopoly businesses". Moreover, in Asian economies, Central Asia Regional Economic Cooperation (2005: 17) refers to regulations on electricity sectors as: "Countries vary with respect to the sequencing of sector reforms. However, the elements of these reform packages either already include or are likely to include the following: ... (ii) vertical unbundling, which includes measures to make the performance of each company transparent and to publish transfer prices among generation, transmission, and distribution...".

2. Several microeconomic studies present the analytical structure of this utility formulation (e.g., Singh and Vives, 1984; Hackner, 2000).

3. More specifically, net utility for the consumer is described as:

$$U(q_1, q_2, ..., q_n) - \sum_{i=1}^{n} p_i q_i = a \sum_{i=1}^{n} q_i - \left(b \sum_{i=1}^{n} q_i^2 + 2b\theta \sum_{i \neq j} q_i q_j \right)/2 - \sum_{i=1}^{n} p_i q_i .$$

   Maximization of this equation with respect to $\{q_1, q_2, ..., q_n\}$ yields the inverse demand function represented by equation (2).

4. This problem is equivalent to one in which all firms are decentralized and each firm is forced to transfer products from the upstream division to the downstream division at a unit price equal to marginal (average) cost, c.

5. No asymmetric equilibrium between firms with respect to the organizational regime arises. For example, there exists no equilibrium such that some firms choose centralization while others prefer decentralization. Recall that a centralized firm is equivalent to a decentralized firm that must transfer products to the downstream division at the marginal cost, c. Therefore, firms opt weakly for decentralization because they can control the internal transfer price as a strategic variable in addition to the retail price.

6. Although Figure 3 shows a curve with the values of n varying between 2 and 10, one may confirm the negative correlation between n and θ by drawing a similar three-dimensional graph with n varying from 2 to a finite integer based on ΔSS in Proposition 3.

7. Although we do not give formal proof that θ_r moves leftward according to n, one may confirm this tendency by drawing a graph like Figure 4 with a fixed integer of n based on r_i^D in Proposition 2.

8. Although we do not provide formal proof that θ_p moves leftward as n increases, one may confirm this tendency by drawing a graph like Figure 5 with a fixed integer of n based on p_i^C, p_i^D, and p^{COL} in Lemma 1 and Propositions 1 and 2.

9. Gal-or (1990) proves that coexistence of asymmetric organization regimes, i.e.,

centralization and decentralization, never emerges as long as firms' strategic variable is price and neither a manufacturer nor a retailer incurs fixed costs to handle the product.

10. This can be confirmed by using a mathematical software package.

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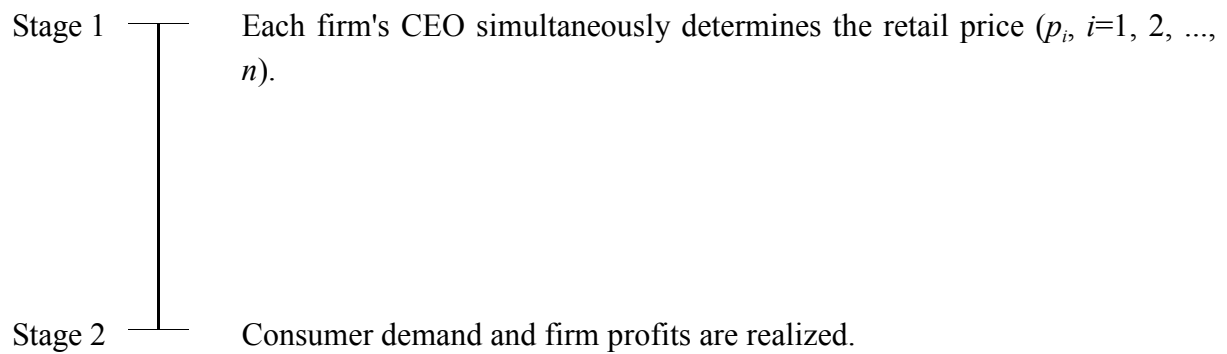
Table 1.

Nomenclature

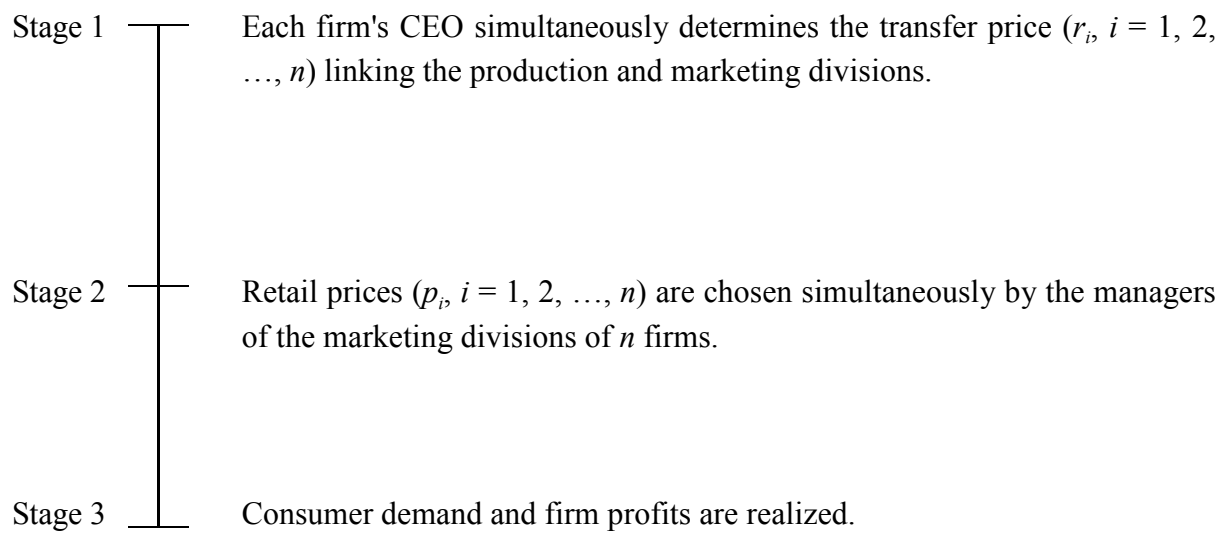|	
p	retail price per unit of the product
r	transfer price per unit of the product
c	marginal (average) cost of the product
a	positive constant greater than *c*
b	positive constant
θ	degree of homogeneity of the product supplied by firms (1−*θ* is the degree of product differentiation.)
q	quantity of the product
n	number of firms
CS	consumer surplus
SS	social surplus
Δ*CS*	difference calculated by subtracting consumer surplus under centralization from that under decentralization
Δ*SS*	difference calculated by subtracting social surplus under centralization from that under decentralization
π	profit
Π	joint profits among all firms
π_2	profit for the downstream marketing division of a decentralized firm
Δ	difference operator, between decentralization and centralization values
i	subscript that indexes firm
C	superscript that denotes equilibrium under centralization
D	superscript that denotes equilibrium under decentralization
COL	superscript that denotes equilibrium under collusion

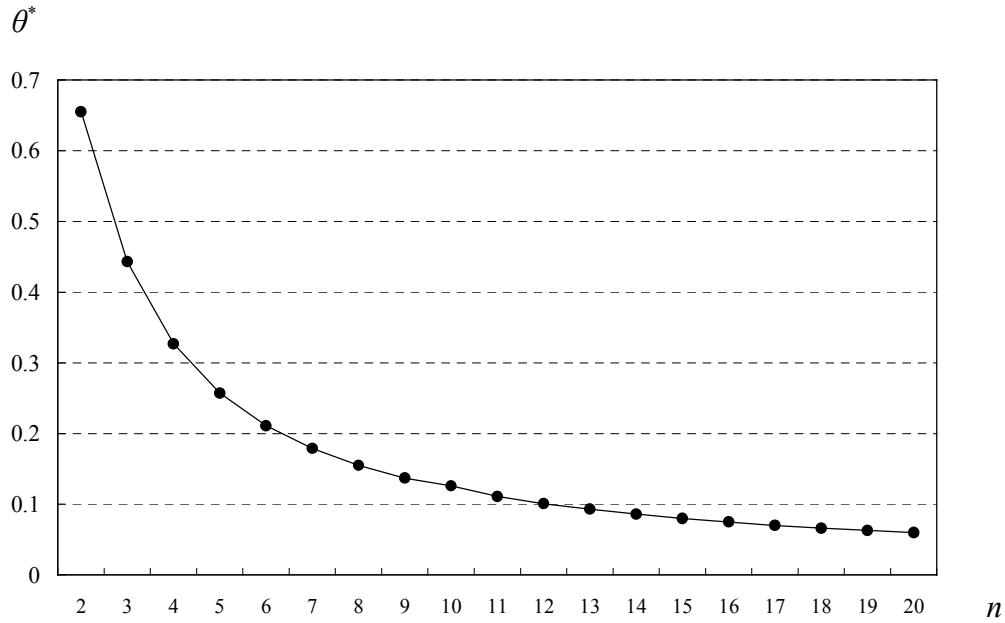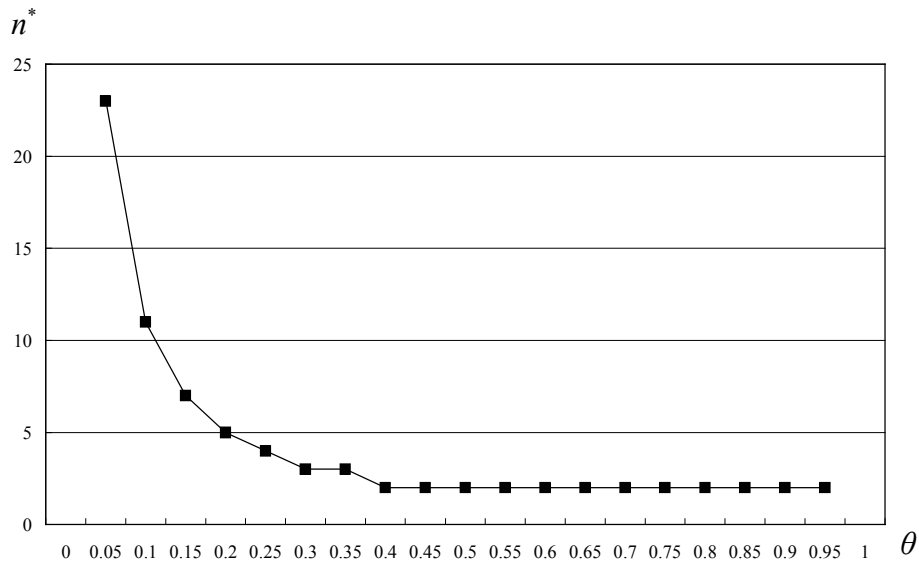**Figure 1.**

Timeline of events

(1) Centralization

Stage 1 ——— Each firm's CEO simultaneously determines the retail price (p_i, i=1, 2, ..., n).

Stage 2 ——— Consumer demand and firm profits are realized.

(2) Decentralization

Stage 1 ——— Each firm's CEO simultaneously determines the transfer price (r_i, i = 1, 2, …, n) linking the production and marketing divisions.

Stage 2 ——— Retail prices (p_i, i = 1, 2, …, n) are chosen simultaneously by the managers of the marketing divisions of n firms.

Stage 3 ——— Consumer demand and firm profits are realized.

Figure 2.

Trajectory of n and θ that minimizes ΔSS when one variable is fixed

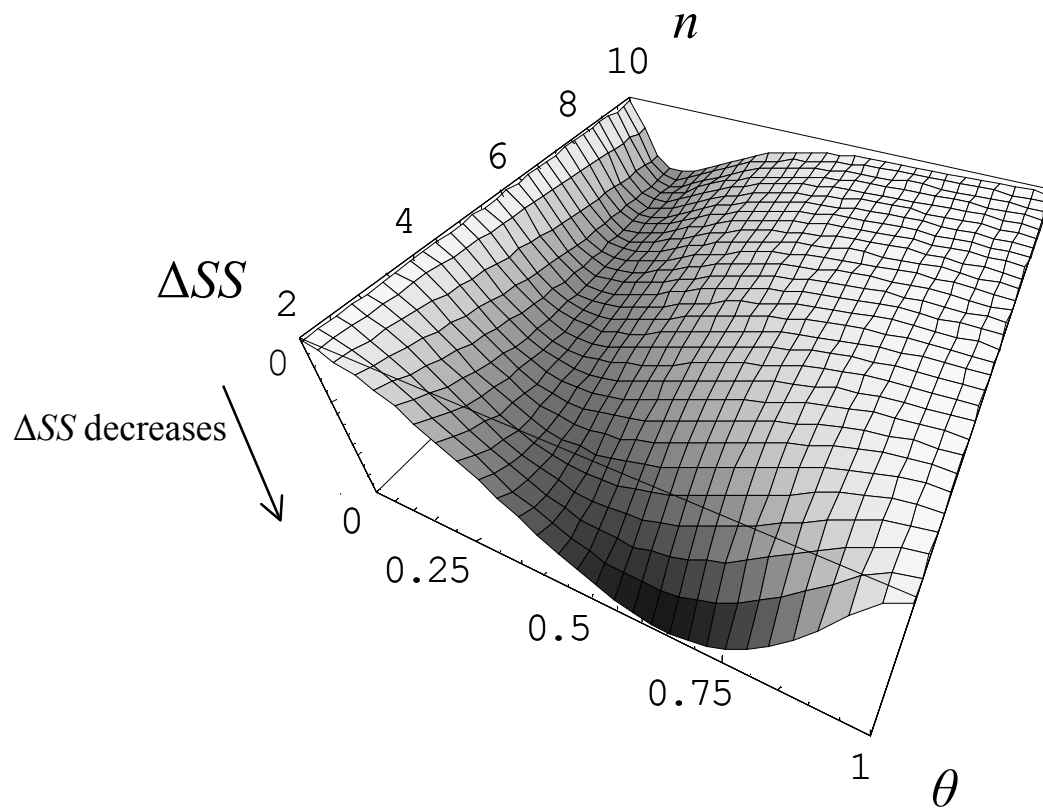(A) Trajectory of product differentiation, θ^*, that minimizes ΔSS when n is given

(B) Trajectory of the number of firms, n^*, that minimizes ΔSS when θ is given
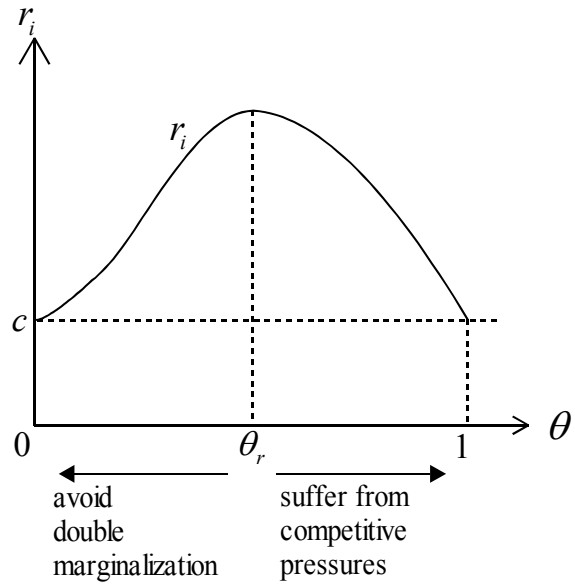
Figure 3.
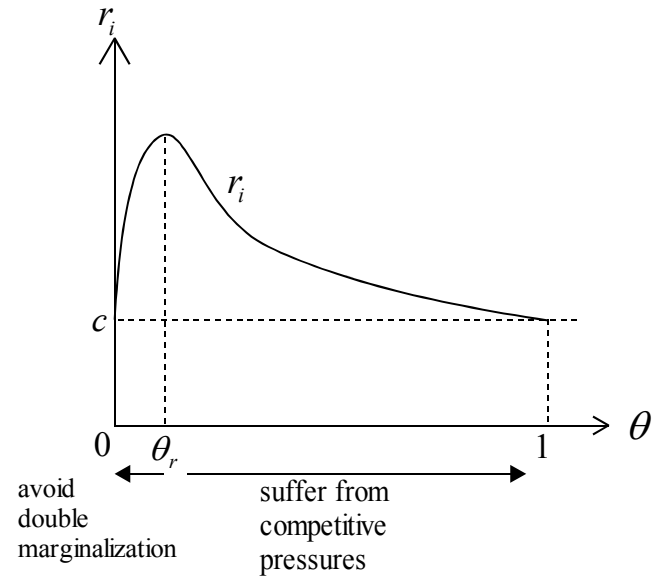
Curve for social welfare difference, ΔSS

Note: The figure suggests that the values of θ and n that track the bottom of the curved surface are negatively correlated. Recall that a, b, and c do not affect the combinations of θ and n that lie on the bottom of the curved surface according to ΔSS presented in Proposition 3.

Figure 4.

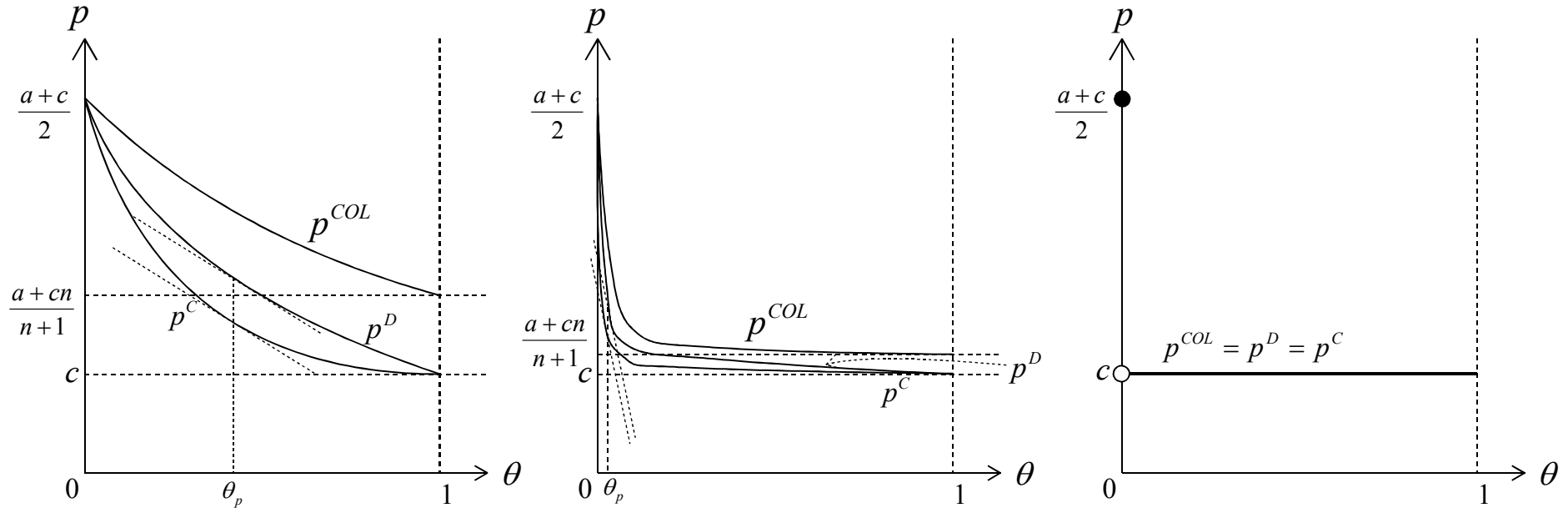Deviation of transfer price from marginal cost

Panel A: number of firms, n, is small   Panel B: number of firms, n, is large

Figure 5.

Prices under decentralization, centralization, and collusion

Panel A: *n* takes a relatively small number   Panel B: *n* takes a relatively large number   Panel C: *n* diverges to infinity

Note: θ_p represents the degree of product differentiation that maximizes the deviation of the price between decentralization and centralization. As *n* increases, the graphs of equilibrium retail price under each organization regime change from Panel A to Panel B, and further from Panel B to Panel C.