THE IMPACT OF AN INFORMATION LINKAGE SYSTEM ON A FIRM'S ORGANIZATION STRUCTURE, TRANSFER PRICE AND PROFIT

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ABSTRACT

This study investigates the impact of costless information linkage systems on the organization structure, transfer price and profit of companies. These firms typically consist of a headquarters (HQ) and downstream divisions (DD). Recent research on management accounting emphasizes the importance of a firm choosing the optimal level of internal transfer price and organization structure to maximize its total profit. The study constructs an analytical model to analyze the optimal decisions a firm that faces price competition in a product market needs to make. Our mathematical analysis demonstrates that a firm's profit declines when it adopts an information linkage system that mitigates the information asymmetry between the HQ and DD in a competitive price environment. This is a novel result, since prior management accounting research indicates that information linkages between intra-organization divisions improve the firm's total profit. The result of this study is attributed to the loss of incentive for tacit collusion between competitors. The firm has no incentive to decide on the decentralization of decision rights by adopting an information linkage system. Therefore, this research has a significant implication for management accounting practice. Firms should exercise caution when adopting an information linkage system, as – under specific economic conditions – it may not improve their profits.

INTRODUCTION

Recent events show the increased significance of transfer prices in operational decisions, particularly for large firms such as multinationals, which are composed of multiple divisions. For example, multinational enterprises (e.g., Starbucks Corporation) use transfer prices to avoid paying tax on profits. To curtail tax avoidance, the Organisation for Economic Co-operation and Development (OECD) established guidelines for multinational transfer pricing practices. In addition, General Motors Company (GM) and Panasonic use transfer prices to optimize their divisional operations and profits. Transfer prices allow managers to evaluate the manufacturing division's performance as a cost or profit center. While the firm can evaluate divisional performance effectively and accurately using transfer pricing, it is difficult to determine the optimal level of transfer pricing for a firm composed of divisions. Hence, in practice, firms are interested in determining optimal transfer pricing under specific conditions. From this fact, transfer prices are undoubtedly an essential factor in contemporary management accounting practice. Selecting an optimal transfer price can improve a firm's profit from a management accounting perspective, and is a popular topic in empirical management accounting research (e.g., Chan and Lo, 2004; Tang, 1992; Terzioglu and Inglis, 2011).

This study expands on the analysis of Narayanan and Smith (2000), a seminal work in the literature on strategic transfer pricing. Narayanan and Smith investigated the optimal choice of transfer price and organization structure under asymmetric information and differential tax rates between inter-firm divisions. This paper demonstrates how the optimal transfer price and organization structure may be determined based on their results.

In addition, following Baiman and Rajan (2002), this paper introduces an information linkage system into the model. In practice, information linkage systems (e.g., the point-of-sale (POS) data system used in Japanese convenience stores and the mileage system employed in the airline industry) provide information to the management division. While Baiman and Rajan (2002) examine the impact of the information linkage system between buyers and suppliers, this study analyzes its effect between the headquarters (HQ) and downstream division (DD) of a firm, both of which belong to the same organization.

Narayanan and Smith (2000) show that competition and asymmetric information lead to a decentralized organizational structure, a transfer price above the marginal cost, asymmetric information, and a differential tax rate. Firms facing price competition aim to set a higher price by strategic complementarity. If firms choose decentralization, they can set a higher transfer price via tax avoidance and information asymmetry under specific conditions. In addition, information asymmetry leads firms to choose a decentralization strategy to use the DD's private information. This study assumes that costless information linking systems mitigate the information asymmetry between the HQ and DD. Hence, in Narayanan and Smith's (2000) model, if the firm adopts an information linking system, it loses the incentive to choose a decentralized organizational structure. Therefore, in this case, the firm must be efficiently managed by the HQ, because the HQ has the decision rights and demand information. While it is believed that information linkage improves the effectiveness of a firm in practice, Baiman and Rajan (2002) construct an incomplete contract model and show that an information linkage system cannot improve the firm's profit under specific conditions. This viewpoint indicates that there is some possibility of a decline in the firm's profit if it uses an information linkage system under specific economic situations.

This research examines the firm's choices of organization structure and level of transfer price, as well as the economic consequences of using an information linkage system. The economic analysis of transfer pricing with price competition from a managerial viewpoint dates back to Hirshleifer (1956), where the internal transfer price is set equal to the marginal cost to alleviate any attendant double-marginalization problem. Since the work of Hirshleifer (1956), others have analyzed the optimal level of the transfer price in management accounting using the market competition model (e.g., Alles and Datar, 1998; Arya and Mittendorf, 2007; Autrey and Bova, 2012; Fjell and Foros, 2008; Göx, 2000; Johnson, Löffler and Pfeiffer, 2016; Matsui, 2011, 2012, 2013; Narayanan and Smith, 2000; Shor and Chen, 2009). Most prior studies consider the optimal level of transfer pricing by comparing the marginal cost and discussing the cost-based transfer price (e.g., Alles and Datar, 1998; Matsui, 2011, 2013). This is because Tang (1992) provides important empirical evidence on transfer pricing practice and, specifically, the relationship between the transfer price and a cost accounting system. Because the model in this study pertains to strategic

transfers, it can be classified as belonging to the literature on strategic transfer pricing.

Narayanan and Smith (2000) and Göx (2000) consider the choice of organization structure in strategic transfer pricing. In practice, many firms choose a decentralized organization and aim to increase direct contact with customers. Notably, convenience stores' DDs (retail stores) in Japan are centralized in terms of decision rights. Therefore, retail stores have no right to decide the market price. Göx and Shiller (2007) also suggest that strategic transfer pricing research should examine firms' organization structure decisions. Another important assumption in strategic transfer pricing research relates to the existence of information asymmetry between divisions (e.g., Narayanan and Smith, 2000; Göx and Schöndube, 2004). In addition, Narayanan and Smith (2000) only assume simultaneous information asymmetry between divisions and the choice of organization structure under price competition. It is argued that a decentralized organization is caused by information asymmetry in management accounting. Hence, management accounting research requires a model that simultaneously includes information asymmetry and organization structure.[1]

In contract theory, the existence of information asymmetry between the principal and agent lowers the principal's payoff, in most cases, because of agency costs or information rent. Hence, prior studies investigate ways to mitigate this information asymmetry and secure efficient contracts (e.g., Baiman and Rajan, 2002). An information linkage system is one way to mitigate the information asymmetry between the principal and agent. This system helps the firm obtain the private information of agents (e.g., a customer relationship management (CRM) system in pharmacies, or a POS data system in convenience stores). In addition, some firms, such as NEC Corporation, provide information linkage systems between divisions. From the perspective of management accounting, open book accounting, as in the construction industry in the U.K., or target costing, as practiced by Toyota Motor Corporation, improves a firm's profit and is recommended to achieve a high firm value. This study considers an information linkage system that mitigates the information asymmetry between the HQ and DD.

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1   Studies on strategic transfer pricing that use the contract theory are an exception; they assume information asymmetry (e.g., Baldenius, 2000; Holmstrom and Tirole, 1991).

This research demonstrates that a counterintuitive result that an information linkage system lowers a firm's profit under a specific economic condition. This is a novel result, not found previously in the literature on strategic transfer pricing under price competition environments. Information linkage systems are adopted under centralized structures. Hence, the firm has no incentive to choose a higher market price, because the level of the transfer price is equal to the market price or marginal cost. Therefore, under price competition, a firm cannot set a higher price by tacit collusion, as shown by Narayanan and Smith (2000). As a result, adopting a costless information linkage system in transfer pricing causes the firm's profit to decline.

This result suggests significant implications for management accounting practice. The result in this paper demonstrates that adopting an information linkage system lowers a firm's profit, while previous studies on management accounting argue the opposite result, namely that adopting such a system improves a firm's profit. When a firm adopts an information linkage system, the DD cannot decide the market price. Hence, it uses the transfer price, leading to large tax avoidance, which distorts the optimal resource allocation and causes tacit collusion. From the perspective of strategic transfer pricing research, the result in this study suggests that adopting an information linkage system creates these negative effects. Therefore, a firm must be cautious when adopting such systems in price competitive environments.

The remainder of the paper is organized as follows. Section 2 describes the setting of the model in this paper. Section 3 constructs the model and presents results in this study. Lastly, section 4 concludes the paper.

MODEL

In this section, an analytical model which describes transfer pricing in divisionalized firms is proposed. This study assumes two firms, Firms 1 and 2, that engage in differentiated price competition in the market. There are two divisions in each firm: HQ and DD. The HQs produce intermediate goods with a marginal cost c, which the DDs sell in the final goods market at price p. The DD adds value to the intermediate goods before selling them in the final goods market. However, both this value and the cost of adding

value are normalized to 0. Table 1 provides the necessary notations. In addition, Figure 1 illustrates the situation analyzed in this study.

Firm *i* faces the following demand function:

$$q_i = a - p_i + \theta p_j \qquad (1)$$

where denotes the demand of firm *i* (=1, 2); *a* is a positive constant, greater than the cost parameter $c(a>c)$; and p_i and p_j are the market price of firm *i* and firm *j*, respectively, where *j* is a competitor to *i*. Hereafter, (i, j) are represented as either (1,2) or (2,1). The degree of substitution between production is denoted as $\theta \in (0, 1)$. When θ approaches 0, firm *i* engages in a monopoly. Then, *a* is a random valuable with density function $f_a(a)$, distribution function $F_a(a)$, mean μ_a, variance σ^2_a, and support $[a, \bar{a}]$.

Table 1: Notations

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	Profit for the downstream market division in a firm
	Joint profit for a firm
i	Subscript that indexes the firm
j	Subscript that indexes the firm that is different from firm *i*
h	Subscript that indexes the firm's HQ
d	Subscript that indexes the firm's DD
p	Market price
q	Quantity
c	Direct manufacturing cost per unit
μ	Average of random variable
σ^2	Variance of random variable
T	Transfer price
t	Tax rate
τ	Profit rate after tax
a	Positive constant greater than *c*
0	Organization structure ($0_i \in$ {C, D}. is centralization and *D* is decentralization)
θ	Substitutability of products supplied by the two firms (0<θ<1) (1-θ is the degree of product differentiation)
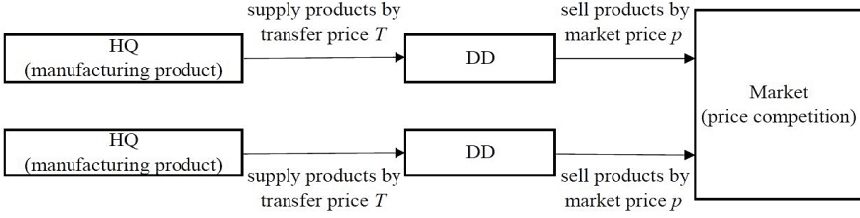
Figure 1: Scenario Studied in This Paper

The HQ's manufacturing cost is per unit of product produced, where is a random variable with density function $f_c(c)$, distribution function $F_c(c)$, meam μ_c, variance σ_c^2 and support [c, c]. This model assumes $a - c > 0$. That is, demand continues to be positive (a) for the lowest possible realization of the demand function intercept, and (b) at a price equal to the highest possible realization of the marginal cost. This research assumes that the DD knows the manufacturing cost parameter c.

The profit function of firm $i's$ (= 1, 2) DD (π_i^{DD}) is as follows:

$$\pi_i^{DD} = (p_i - T_i)q_i, \tag{2}$$

where T_i ($\geq c$) denotes the transfer price. The performance of the DD is evaluated in terms of this profit. Next, the joint profit function of firm i is as follows:

$$\Pi_i = \pi_i^{DD} + (T_i - c)q_i$$

$$= (p_i - c)q_i \tag{3}$$

Following Narayanan and Smith (2000), the HQ and DD in this study face different tax jurisdictions. The DD's profits are taxed at rate t_d, while those in the HQ's jurisdiction are taxed at rate t_h. Let $t_{min} = min\{t_d, t_h\}$. Let $\tau_k = 1 - t_k$, $k \in \{h. d, min\}$. Then:

$$\pi_i^{DD} = \tau_d(p_i - T_i)q_i, \tag{4}$$
$$\Pi_i = \tau_d(p_i - T_i)q_i + \tau_h(T_i - c)q_i, \tag{5}$$

Each decision-maker attempts to maximize this profit function.

This model considers two organizational structures: $0_i \in \{D, C\}$. In the first, the firm centralizes the pricing decision (strategy *D*). That is, the HQ sets the market price *p*. In the second, the firms decentralize the organizational structure by making the DD a profit center and delegating the pricing decision to it (strategy *C*). The HQ sets the transfer price *T* per unit of product purchased by the DD. The transfer price is used to compute the sales office's profit. This study assumes that the firms undertake an explicit contract with the DD, which specifies the transfer price and the performance measure of the DD. When the HQ choose strategy *D*, the DD decides the market price *p* after observing *a* and *T* in order to maximize its profits. When the HQ choose strategy *C*, the HQ decides the market price *p* after observing the marginal manufacturing cost *c*, but without observing *a*, in order to maximize the firm's total profit. Under both strategies, the HQ chooses the transfer price *T* after observing the marginal manufacturing cost *c*, but without observing *a*, in order to maximize the firm's total profit. In addition, when strategy *C* is chosen, the transfer price is *T = c* or *T = p*. This assumption is the same as that of Narayanan and Smith (2000). The DD observes the realization of *a*, but the HQ knows only its distribution.

In addition, this study considers an information linkage system, such as the CRM system in pharmacies[2]. When information is shared between the HQ and DD, a signal informs the HQ about the demand information, which is private to the DD. Hence, when the firm adopts an information linkage system and chooses centralized strategy *C*, the HQ can decide the market price after observing *a*. This is the only difference between the approach in this paper and that of Narayanan and Smith (2000). For simplification, it is assumed that the HQ can obtain full information when the firm uses an information linkage system. In addition, this research assumes that the information linkage system is adopted exogenously.

Lastly, the following timeline of events are proposed. The use of the information linkage system is denoted as IL, and the lack of it, as NIL. The timeline of events without information linkages (NIL) is depicted in Figure 2.

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2   For simplicity, there is no cost to obtain the DD's private information in this research.

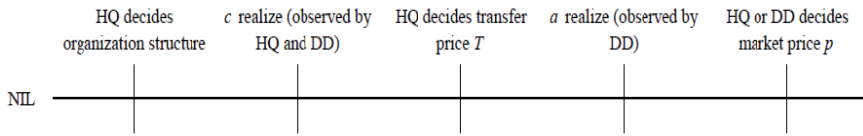| HQ decides organization structure | c realize (observed by HQ and DD) | HQ decides transfer price T | a realize (observed by DD) | HQ or DD decides market price p |

NIL

Figure 2: Timeline of Events Without the Information Linkage System

In the first step, the HQ decides on the organization structure. Second, the manufacturing cost parameter c is realized and observed by the HQ and the DD. Third, the HQ decides the transfer price T. Next, a is realized and observed by the DD. Lastly, the HQ or DD decide on the market price p. Without the information linkage, the timeline of events is the same as that in Narayanan and Smith (2000). Figure 3 shows the timeline of events with the information linkage (IL).
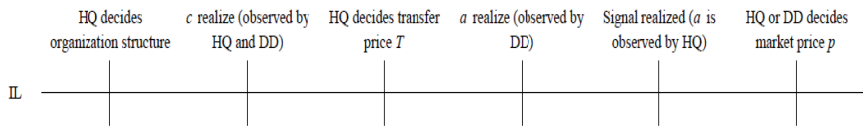
| HQ decides organization structure | c realize (observed by HQ and DD) | HQ decides transfer price T | a realize (observed by DD) | Signal realized (a is observed by HQ) | HQ or DD decides market price p |

IL

Figure 3: Timeline of Events with the Information Linkage System

If information is shared between divisions, it is added to the step of signal observation (observation of a) by the HQ. In addition, this model assumes that the firm does not pay the cost to obtain DD's private information (and adopt information linkage system). Hence, HQ can obtain information by using an information linkage system.

MODEL ANALYSIS

Here, the constructed model in the prior section is analyzed. First, the equilibrium when the competitor's transfer price and organization are not observable is derived in this section. Narayanan and Smith (2000) also analyze this situation. Note that as per management accounting practice, it is valid to examine an unobservable situation. In the basic model setting, this study assumes that each decision-maker has to decide strategies without observing all competitors' strategies. In addition, decision-makers can observe only their own firms' strategies before deciding on the pricing strategy. This is reasonable, given the especially unique outcome Narayanan and Smith (2000) obtain in the unobservable situation.

First, the analysis characterizes the equilibrium without the information linkage system. The equilibrium is identified by considering, for each firm, the deviation from any organization structure, transfer price, and price. Given each firm's decentralized strategy , the optimal strategies are considered the decision of the DD. Strategy is chosen by firms in an equilibrium when

$$\sigma_a \geq \frac{(2-\theta)^2 \tau_h (2\tau_h - \tau_d)(\tau_h - \tau_d)((\mu_a - (1-\theta)\mu_c)^2 + (1-\theta)^2 \sigma_c^2)}{\tau_d \left((4-3\theta)\tau_h - 2(1-\theta)\tau_d\right)^2} = \dot{\sigma}_a,$$

(6)

holds. Then, firm 's HQ and DD choose their strategies, as follows:

$$T_i = T_j = c + \frac{2(\tau_h - \tau_d)(\mu_a - (1-\theta)c)}{(4-3\theta)\tau_h - 2(1-\theta)\tau_d},$$ (7)

$$p_i = p_j = \frac{((4-3\theta)\tau_h - 2(1-\theta)\tau_d)a + 2(\tau_h - \tau_d)\mu_a + (2-\theta)\tau_h c}{(2-\theta)((4-3\theta)\tau_h - 2(1-\theta)\tau_d)}, \quad \text{and} \quad (8)$$

$$\Pi_i = \Pi_j = \frac{\tau_h^2(2\tau_h - \tau_d)((\mu_a - (1-\theta)\mu_c)^2 + (1-\theta)^2 \sigma_c^2)}{\left((4-3\theta)\tau_h - 2(1-\theta)\tau_d\right)^2} + \frac{\tau_d \sigma_a^2}{(2-\theta)^2}.$$ (9)

This result is a reproduction of Narayan and Smith's (2000) Propositions 5 and 6 (Narayanan and Smith, 2000, 511–512). In this case, when $\tau_h > \tau_d$, the transfer price T_i exceeds the marginal cost. Equations (7)–(9) denote the optimal strategies and profit when the decentralization strategy is adopted. Hereafter, this research focuses on the case in which $\tau_h > \tau_d$ holds, which is the unique outcome in Narayanan and Smith (2000). This study calls this case the decentralization equilibrium. Notably, the decentralization equilibrium is unique in (6). Hence, this paper denotes the strategy without information linkage as (0_1^{NIL}, 0_2^{NIL}) and when $\sigma_a \leq \sigma_a^2$ holds, firms choose equilibrium strategies (0_1^{NIL}, 0_2^{NIL}) = (*D, D*).

This result indicates that different tax rates between divisions cause the transfer price to exceed the marginal cost. The firm can choose a transfer price that exceeds the marginal cost only when it has a decentralized structure. Narayanan and Smith (2000, 511) show that decentralization is caused by asymmetric information. Hence, assuming asymmetric information, the transfer price exceeds the marginal cost owing to the effect of the differential tax rates.

First, the logic of the decentralization equilibrium under information asymmetry is explained to understand the property of this equilibrium. In this case, information (i.e., the amount of information) assumes great significance in the decision of the HQ. If the information is important (the variance of the demand information σ_a^2 is large), the HQ wants to use the demand information effectively. Hence, the HQ chooses decentralization to utilize the DD's private information and to decide on the market price efficiently. Past studies on strategic transfer pricing show that the HQ would ordinarily choose centralization when competitors' strategies are unobservable, because centralization can mitigate the selfish behavior of the DD's manager and steal the competitor from a high price.

Second, it explains why the level of the transfer price increases with differential tax rates (i.e., a higher tax under the jurisdiction of the DD). When the after-tax profit of the DD is lower than that of the HQ, the firm has an incentive to transfer profits to the HQ from the DD. As a result, the HQ sets a higher transfer price, which exceeds the marginal cost, in order to transfer the profit between divisions. Then, the higher transfer price can improve the firm's total profit by affecting the market price, because the DD's cost is higher than the transfer price, which is equal to the marginal cost. In spite of the inability to observe a competitor's transfer price, the level of the transfer price exceeds the marginal cost. Narayanan and Smith (2000) argue that this results in tacit collusion.

Next, the analysis shows the firm's decision when it adopts an information linkage system. The deviation incentive from a centralized strategy to a centralized competitor is considered to analyze the equilibrium. Accordingly, the analysis compares the equilibrium outcomes for firms with and without an information linkage system. The analysis first examines the equilibrium outcome of firm i with an information linkage system. All proofs appear in the Appendix.

Proposition 1. For a firm with an information linkage system, $(0_1^{NIL}, 0_2^{NIL}) = (C, C)$ is chosen in equilibrium. Then, $\tau_h > \tau_d$, and firm i chooses the market price strategy

In addition, $(0_1^{NIL}, 0_2^{NIL}) = (D, D)$ is also chosen in equilibrium when

$$\sigma_a^2 \geq \frac{1}{4(\tau_h - \tau_d)\big((4 - 3\theta)\tau_h - 2(1 - \theta)\tau_d\big)^2}\Big((2 - \theta)^2\tau_h\Big((\tau_h$$
$$- \tau_d)\big(4(2\tau_h - \tau_d)(\mu_a - (2 - \theta)\mu_c)\mu_a$$
$$+ \big((8 - 8\theta + \theta^2)\tau_h - (2 - \theta)^2\tau_d\big)\mu_c^2\big)\Big)$$
$$- \big((8 - 16\theta + 9\theta^2)\tau_h - 2(6 - 8\theta + 3\theta^2)\tau_h\tau_d + (2 - \theta)^2\tau_d\big)\sigma_c^2\Big)$$

holds.

From Proposition 1, it notes that the information linkage system increases the firm's incentive for centralization at its HQ. Except for specific conditions, the HQ does not choose the centralization strategy without an information linkage system. However, when such a system is adopted, it clearly notices its effect, because each firm chooses the centralization strategy. In addition, from Proposition 1, it finds that there exist multiple equilibria. However, this study does not pay attention to the decentralized equilibrium because this outcome does not differ from that in the absence of an information linkage system.

From the centralized equilibrium outcome of Proposition 1, the following proposition is obtained by comparing the equilibrium profits.

Proposition 2. With an information linkage system and a centralized outcome, when

$0 < \theta < 1$, $\tau_h > \tau_d$, and

$$54 - 146\theta + 772\theta^2 + 16\theta^3 - 10\theta^4 < 0,$$
$$\sigma_a \leq \sigma_a^{\,2} \leq \sigma_a$$

where

$$\dot{\sigma}_a = \frac{(2 - \theta)^2\tau_h(2\tau_h - \tau_d)(\tau_h - \tau_d)\big((\mu_a - (1 - \theta)\mu_c)^2 + (1 - \theta)^2\sigma_c^2\big)}{\tau_d\big((4 - 3\theta)\tau_h - 2(1 - \theta)\tau_d\big)^2},$$

$$\hat{\sigma}_a = \frac{\big((\mu_a - (1 - \theta)\mu_c)^2 + (1 - \theta)^2\sigma_c^2\big)\tau_h\Big((8 - \theta(16 - 7\theta))\tau_h - 4(1 - \theta)^2\tau_d\Big)}{\big((4 - 3\theta)\tau_h - 2(1 - \theta)\tau_d\big)^2}$$

holds. The firm's equilibrium profit declines from the profit realized in a decentralized equilibrium without information linkages.

This result is unique and essential when considering the effect of information linkage systems. Studies on management accounting namely open book accounting or target costing, argue that information linkage systems improve a firm's profit. Quick information linkages are crucial in management accounting practice, as in a POS data system in a convenience store. However, from $54 - 146\theta + 772\theta^2 + 16\theta^3 - 10\theta^4 < 0$, this study shows that information linkages lower a firm's profit under a specific condition, namely when the degree of product differentiation is low. Hence, the firm engages in intense competition. In the decentralization equilibrium, the market price increases by transfer pricing and, therefore, the decline in profit is lower than that in the centralization equilibrium.

The economic intuition of this result is as follows. Information linkage systems allow the HQ to obtain information from the DD[3]. When the HQ can obtain this information, its incentive to centralize increases. When the HQ chooses the centralization strategy, the transfer price is not an internal solution. Then, the firm cannot increase the market price. As a result, the market price in the centralized equilibrium is lower than that in the decentralized equilibrium. Hence, each firm's profit declines in a centralized equilibrium.

The condition of holding Proposition 2 is affected by the importance of the private information of the DD (i.e., the variance of the demand information, σ_a^2). If the variance of the demand information, σ_a^2, is extremely small, the firm loses the incentive to decentralize without the information linkage system. Thus, in this case, firms have no incentive to choose the tacit collusion strategy. In addition, when the variance of the demand information, σ_a^2, is extremely large, the efficiency of the information linkage system is improved, and the benefit without the system cannot exceed the benefit with the system. Therefore, when the variance of the demand information is of a reasonable degree, the result in Proposition 2 is obtained.

However, the difference in the tax rates between divisions is an important factor to derive the main result in this study. When $\tau_h > \tau_d$ does not

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3   There is no cost to obtain the DD's private information.

hold, the firm cannot improve the firm-wide profit by choosing tacit collusion prices without the information system. Therefore, the profit without the information linkage system is lower, and the result in Proposition 2 cannot be obtained in this model.

In addition, it considers the threshold σ_a, which is difference in profit between the decentralized equilibrium without the information linkage system and the centralized equilibrium with the information linkage system. Then, following propositions are obtained:

Proposition 3 Threshold σ_a, which is the difference in profit between $(0_1^{NIL}, 0_2^{NIL}) = (C, C)$ and $(0_1^{NIL}, 0_2^{NIL}) = (D, D)$, increases with an increase in τ_h when

$$\tau_h > \frac{2(1-\theta)^2}{4 - 9\theta + 4\theta^2}\tau_d$$

holds.

Proposition 4 Threshold σ_a, which is the difference in profit between $(0_1^{NIL}, 0_2^{NIL}) = (C, C)$ and $(0_1^{NIL}, 0_2^{NIL}) = (D, D)$, decreases with an increase of τ_d when

$$\tau_d < \frac{4 - 9\theta + 4\theta^2}{2(1-\theta)^2}\tau_h$$

holds.

Propositions 3 and 4 indicate that the difference in profit between $(0_1^{NIL}, 0_2^{NIL}) = (C, C)$ and $(0_1^{NIL}, 0_2^{NIL}) = (D, D)$ is affected by the change in the after-tax rate. From Propositions 3 and 4, it notes that the effect of an increase in the after-tax rate of the HQ and a decrease in the after-tax rate of the DD has the same impact on the threshold σ_a. In addition, because firms transfer the profit between divisions using transfer prices, increasing the transfer price, which is affected by changes in the tax rate, affects the market price. Thus, the effect of improving the profit by changing the market price is different between the decentralized and the centralized equilibrium. Narayanan and Smith (2000) show that increasing the tax rate of the DD,

t_d (decreasing the after-tax rate of the DD, τ_h) improves a firm's profit because of the increase in the transfer price and the market price when $\tau_h > \tau_d$ holds. Hence, the value of the threshold σ_a, which is the difference when the centralized equilibrium profit is subtracted from the decentralized equilibrium profit, is increased when the decentralized equilibrium profit tends to improve. In this analysis, the profit in the decentralized equilibrium is improved by decreasing τ_d (increasing τ_h). Hence, Propositions 3 and 4 is obtained.

CONCLUSION

This study, investigated the economic impact on firms of information linkage systems, which mitigate the information asymmetry between firms' divisions. These results show that an information linkage system lowers a firm's profit under specific conditions, owing to a decrease in the market price. With an information linkage system, the firm's HQ has a strong incentive to centralize, because the HQ can obtain the DD's private information. Hence, the level of the transfer price is not decided as an internal solution, and the market price is not increased. As a result, firms cannot improve their profit because they cannot choose a higher price.

This study makes an important contribution to strategic transfer pricing research. Following Narayanan and Smith (2000), this study shows the importance of information asymmetry in strategic transfer pricing. This research proves that adopting an information linkage system can lead to a decline in a firm's profit under a specific economic condition. This is a significant result because in management accounting practice, information linkages typically improve firms' profits. Thus, this study posits that firms should be cautious when adopting information linkage systems.

This study has several limitations. First, it considers the problem using specific economic assumptions, such as a certain number of firms and the shape of the demand function. In addition, the analysis assumes that adopting an information linking system supplies accurate demand information to the HQ. It is difficult to assume that these settings are similar to management accounting practice; however, these settings help simplify the analysis and explain the logic. The second limitation is that the decision to adopt an

information linking system is exogenous. However, this study focuses on the current status of information linking in practice, and shows that adopting such a system does not improve the firm's profit in specific conditions. Therefore, the study can consider the endogenous decision to adopt an information linking system in future research, though it is also important for management accounting research to consider current practices (e.g., Japanese convenience stores) and alert firms of the problem. Consequently, this study questions the adoption of information linking systems in many firms, for example, POS data systems, which is a significant implication in management accounting practice. While firms can obtain information, acquiring information sometimes does not improve the firm's profit. Notably, this study shows that tax avoidance through transfer pricing lowers a firm's profit. Hence, findings suggest that firms must consider the impact of information linking systems on transfer pricing levels.

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APPENDIX

Proof of Proposition 1

First, this proof shows Proposition 1. When $\tau_h > \tau_d$ holds and each firm chooses the centralization strategy, each firm also selects the level of transfer price T_i such that $T_i = p_i$. In addition, each firm chooses the market price as follows:

$$p_i = p_j = \frac{a + c}{2 - \theta} \tag{A1}$$

The firms' total profit is as follows:

$$\Pi_i = \Pi_j = \frac{\tau_h((\mu_a + (1 - \theta)\mu_c)^2 + \sigma_a^2 + (1 - \theta)^2 \sigma_c^2)}{(2 - \theta)^2} \tag{A2}$$

Firm *i's* incentive to deviate from this realized profit is considered in the following analysis.

Given the competitor's strategy (A1), the decision makers in firm *i* face the following object function:

$$\pi_i^{DD} = \tau_d(p_i - T_i)\left(a - p_i + \theta\frac{a + c}{2 - \theta}\right), \tag{A3}$$

$$\Pi_i = \int_{\underline{a}}^{\bar{a}} \left(\tau_d(p_i - T_i) + \tau_h(T_i - c)\right)\left(a - p_i + \theta\frac{a + c}{2 - \theta}\right)f(a)da. \tag{A4}$$

Under decentralization, the DD decides the market price p_i to maximize (A3). The HQ choose the internal transfer price T_i to maximize (A4). As a result, when firm i deviates to decentralization, its DD chooses the deviation market price p_i^{dev} as follows:

$$p_i^{dev} = \frac{2a + \theta c + (2 - \theta)T_i}{2(2 - \theta)}. \tag{A5}$$

In addition, HQ choose the deviation internal transfer price T_i^{dev} as follows:

$$T_i^{dev} = \frac{2\tau_h(\mu_a + c) - \tau_d(2\mu_a + \theta c)}{(2 - \theta)(2\tau_h - \tau_d)}. \tag{A6}$$

Using (A5) and (A6), the deviation profit Π_i^{dev} is obtained as follows:

$$\Pi_i^{dev} = \frac{\tau_h^2(\mu_a - (1 - \theta)\mu_c)^2 + \tau_d(2\tau_h - \tau_d)\sigma_a^2 + (1 - \theta)^2\tau_h^2\sigma_c^2}{(2 - \theta)^2(2\tau_h - \tau_d)} \tag{A7}$$

The difference between (A2) and (A7) is obtained (it subtracts Π_i from Π_i^{dev}).

$$\Pi_i^{dev} - \Pi_i = \frac{(\tau_h - \tau_d)(\tau_h(\mu_a - (1 - \theta)\mu_c)^2 + \sigma_a^2(2\tau_h - \tau_d) + (1 - \theta)^2\tau_h\sigma_c^2)}{(2 - \theta)^2(2\tau_h - \tau_d)}$$
$$> 0. \tag{A8}$$

This result shows that when $\tau_h > \tau_d$ holds, firm i has no incentive to deviate to decentralization. Hence, each firm chooses the centralization strategy in equilibrium. Next, it is considered the condition of unique equilibrium, namely that the decentralization strategy is chosen in equilibrium. In this research setting, asymmetric equilibrium will not exist. Hence, this study considers the symmetric equilibrium. The threshold for the firm not choosing the decentralization equilibrium is obtained as follows:

$$
\begin{aligned}
\sigma_a^2 \leq \frac{1}{4(\tau_h - \tau_d)\big((4 - 3\theta)\tau_h - 2(1 - \theta)\tau_d\big)^2} \Big((2 - \theta)^2 \tau_h \big((\tau_h \\
- \tau_d)\big(4(2\tau_h - \tau_d)(\mu_a - (2 - \theta)\mu_c)\mu_a \\
+ \big((8 - 8\theta + \theta^2)\tau_h - (2 - \theta)^2\tau_d\big)\mu_c^2\big)\big) \\
- \big((8 - 16\theta + 9\theta^2)\tau_h - 2(6 - 8\theta + 3\theta^2)\tau_h\tau_d \\
+ (2 - \theta)^2\tau_d\big)\sigma_c^2 \Big).
\end{aligned}
$$

$$\text{(A9)}$$

When (A9) holds, the centralization equilibrium becomes a unique equilibrium.

Proof of Proposition 2

This proof shows the existence of the condition where the profit of the centralized equilibrium with information linkage is smaller than that of the decentralized equilibrium without information linkage. It is denoted profit for firm i with and without the information linkage system as Π_i^{IL} and Π_i^{NIL}, respectively. It is subtracted Π_i^{IL} from Π_i^{NIL} as follows:

$$
\begin{aligned}
\Pi_i^{NIL} - \Pi_i^{IL} = \\
\left(\frac{\big((\mu_a - (1 - \theta)\mu_c)^2 + (1 - \theta)^2\sigma_c^2\big)\tau_h \big((8 - \theta(16 - 7\theta))\tau_h - 4(1 - \theta)^2\tau_d\big)}{\big((4 - 3\theta)\tau_h - 2(1 - \theta)\tau_d\big)^2} - \sigma_a^2 \right) \\
\times \frac{(\tau_h - \tau_d)}{(2 - \theta)^2} .
\end{aligned}
$$

$$\text{(A10)}$$

When (A10) is negative, total profit without the information linkage system is larger than total profit with the system in equilibrium. The condition for a negative (A10) can be obtained as follows:

$$
\begin{aligned}
\sigma_a^2 \leq \frac{\big((\mu_a - (1 - \theta)\mu_c)^2 + (1 - \theta)^2\sigma_c^2\big)\tau_h \big((8 - \theta(16 - 7\theta))\tau_h - 4(1 - \theta)^2\tau_d\big)}{\big((4 - 3\theta)\tau_h - 2(1 - \theta)\tau_d\big)^2} \\
= \hat{\sigma}_a.
\end{aligned}
$$

$$\text{(A11)}$$

When (A11) and (19) hold simultaneously, proposition is proven. It is considered the outcome of subtracting (19) from (A11) as Σ, but it is difficult to judge whether it is negative or positive. Hence, when Σ is positive, the outcome of subtracting (19) from (A11) is positive. In that case, (A11) and (19) hold concurrently. Σ is calculated as follows:

$$\Sigma = -(8 - 12\theta - 5\theta^2)\tau_d^2 + 2(10 - 14\theta + 5\theta^2)\tau_h\tau_d - 2(2 - \theta)^2\tau_h^2 > 0.$$

It is multiplied Σ and -1, and rewrite (A12) as

$$\Sigma = 2(2 - \theta)^2 \left(\tau_h - \frac{10 - 14\theta + 5\theta^2}{2(2 - \theta)^2}\tau_d\right)^2$$
$$+ \frac{54 - 146\theta + 77\theta^2 + 16\theta^3 - 100\theta^4}{2(2 - \theta)^2}\tau_d^2. \tag{A13}$$

It is considered the condition when (A13) is negative. From (A13), when

$$\tau_h = \frac{10 - 14\theta + 5\theta^2}{2(2 - \theta)^2}\tau_d \tag{A14}$$

holds, the minimum value of Σ is

$$\Sigma = \frac{54 - 146\theta + 77\theta^2 + 16\theta^3 - 100\theta^4}{2(2 - \theta)^2}\tau_d^2. \tag{A15}$$

It is considered that $\tau_h > \tau_d$ holds; hence, the coefficient of τ_d in (A14) must be less than 1. This is true when

$$\frac{3 - \sqrt{3}}{3} < \theta \le 1,$$

holds. In addition, when (A15) is negative, Σ is negative under specific conditions. The denominator of (A15) is positive; therefore, it is demonstrated the sign of $54 - 146\theta + 77\theta^2 + 16\theta^3 - 100\theta^4$ with $0 < \theta \le 1$. It is denoted $54 - 146\theta + 77\theta^2 + 16\theta^3 - 100\theta^4 = \alpha$. Because it is difficult to identify the sign of , it is considered the sign of α with $\theta =$

0 and $\theta = 1$. When $\theta = 0$ holds, the sign of α is positive. When $\theta = 1$ holds, the sign of α is negative. Hence, α must be 0 when $0 \leq \theta \leq 1$. Therefore, (A16) and $\alpha \leq 0$ hold simultaneously. Note that $\alpha \leq 0$ is a more robust condition than (A16). Thus,

$$54 - 146\theta + 77\theta^2 + 16\theta^3 - 10\theta^4 < 0,$$

and $0 \leq \theta \leq 1$ hold simultaneously, and Σ is negative. In this situation, (19) and (A11) hold concurrently. In addition, it is illustrated α when $0 \leq \theta \leq 1$ (Figure A.1).
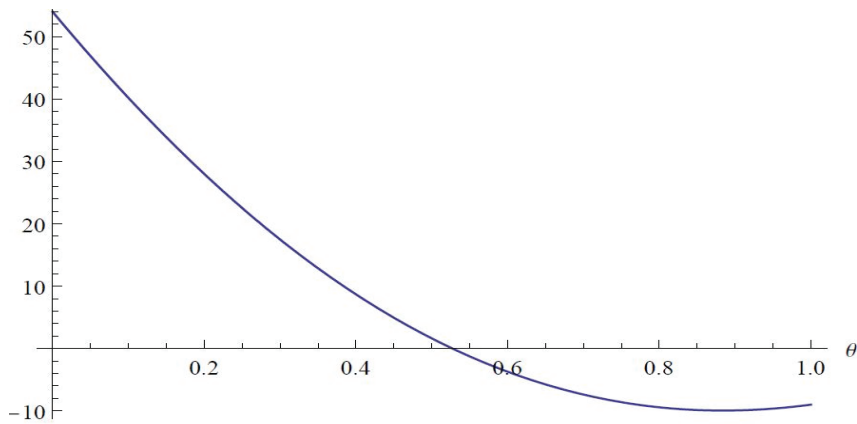

Figure A.1: Plotting 0 ≤ θ ≤ 1 when

As a result, it is found that, in equilibrium, the firm's total profit without the information linkage system is larger than that with the information linkage system.

Proof of Proposition 3 and 4

It was differentiated Eq. (A11) with respect to τ_h or τ_d, and obtained Proposition 3 and 4.