Strategic Allocation of Transfer Pricing Authority

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Abstract

The purpose of this study is to propose a transfer pricing mechanism from the viewpoint of the allocation of organizational decision-making authority in the context of one principal and two agents. This paper provides necessary conditions for the optimal organizational form accompanied by the allocation of decision authorities on the transfer price and quantity to be transferred. The main results show that, when necessary, the principal always allocates the authority to the agent with more valuable private information (greater divisional production cost). The degree of decentralization is negatively associated with the importance of the private information. The principal will choose decentralization when the production costs of two departments are relatively small. When the production costs are sufficiently high, the principal will choose partial delegation. However, centralization is rarely the best organizational form due to the additional constraint of one transfer price in the one-principal-two-agents model. Moreover, without the decision authority over the transfer price may better serve the interest of the principal and agents.

Key Words: transfer pricing, organizational form, organization design, delegation, decentralization, decision authority.

1. Introduction

Transfer pricing is a prevalent practice in most domestic and multinational companies. Evidence shows that more than 91.6% of U.S. Fortune 500 companies employ transfer price, where 46% of firms adopts cost-based price, 37% adopts market price, and 17% adopts negotiated transfer price. (Tan, 1992).[1] Yet, many studies of organization design have ignored the transfer price and implicitly assumed it to be the marginal cost of the intermediate goods.[2] By contrast, since the pioneer study of Hirschleifer (1956) first provided an analytical model of transfer pricing, numerous related studies have explored the effects of tax, agency problem, and investment incentive on transfer pricing;[3] however, they have overlooked the strategic interaction between transfer pricing and organizational structure.[4] The purpose of this study is to address the allocation of decision authority over the transfer pricing along with the choice of organizational structure.

Decentralized profit centers with transfer price delegated to their managers are widely used in practice. Evidence indicates that 79% of U.S. firms and 87.6% of Canadian firms have profit centers (Govindarajan, 1994; Shih, 1996).[5] The major benefits of decentralization are the utilization of the agent's private information, which increases his incentive to acquire information and to participate in the contractual relationship, and the reduction of communication between the principal

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[1] In addition to the use of market transfer price, more than 60% of firms use cost-based or negotiated transfer prices (Anthony and Govindarajan, 2004). Nevertheless, results on research as to whether the subunits in an organization should be vertically integrated are rather mixed, even in the absence of transfer pricing problem.

[2] Alles and Datar (1997) points out that it may be due to that the transfer price does not play a role on firm's objective of profit maximization, revenues less production and operating costs. However, the decentralized marketing department typically maximizes revenue minus the transfer price or the reported costs.

[3] Hirschleifer (1956) suggested that if the external market for the intermediate goods is perfect competition and there are no other costs involved in transacting in the external market, then the efficient transfer price is equal to the market price of the intermediate goods.

[4] The studies of Holmstrom and Tirole (1991) and Narayanan and Smith (2000) are notable exceptions.

[5] In view of separation of ownership and control, the principal (firm owners, CEO) delegate the decision making authority to the agents (management, division managers) to manage the company.

and the agent, while the cost is the loss of control and the incentive problems (Melumad, Mookherjee, and Reichelstein, 1995; Aghion and Tirole, 1997). The self-interested agent with private information may make suboptimal decisions against the principal's objective. The frequently used cost-based transfer price is an example (Horngren et al, 2005). Additionally, where decentralization involves two decision rights and two agents with private information, to whom each decision authority should be allocated and when to do so are the main concerns of this study.

The issue of this paper is to analyze how organizational structure would affect transfer pricing comprising transfer price and quantity to be transferred. Eccles (1985) suggests that the degree of decentralization is an important determinant of the transfer pricing in agency theory. Holmstrom and Tirole (1991) argues that the transfer pricing is an instrument in the overall organization design and should be analyzed in the larger context of organization choice. We further link the transfer pricing mechanism directly to the choice of organizational structure: organizational structures with different degrees of decentralization determine how the decision authorities over transfer pricing are allocated. The principal then chooses the optimal structure. Hence, the individual with the authority over transfer pricing corresponds to his decision-making responsibility, which is essential for a well-designed management control system.[6]

One crucial feature of this study is combining transfer pricing and the more practical context of one principal and two agents in a three-tier hierarchy. There are two reasons for so doing. First, most studies of transfer pricing explore this issue in the context of one principal and one agent in a two-tier hierarchy. The results of the

[6] As transfer pricing is one of the most widely used management control systems, it should fit a firm's organizational structure and individual managers' decision-making responsibilities and motivate managers (Horngren et al., 2005). Compared to a manager of a highly centralized firm, a manager of a highly decentralized firm, is accountable for, and should be evaluated over, a greater share of what is under his control, since autonomy increases with the degree of decentralization.

one principal-one agent model can not be extended to the context of three-tier hierarchy. When there are two agents with private information, the questions of whether to allocate the authority, and how to do so, remain unanswered. This paper provides necessary conditions for the optimal organizational structure together with allocation of authority over transfer pricing. Second, the one-principal-two-agents model induces an additional constraint of one transfer price between two departments, in addition to the problem of information revelation. This constraint may restrict the principal's choice of quantity and objective of profit maximization.

We present a model of transfer pricing and organizational structure that encompasses two stages: the first stage begins with the principal choosing the contract of organizational structure from five feasible organizational forms including decentralization to the upstream divisional manager (agent A_1), or the downstream divisional manager (agent A_2), partial delegation to A_1 or A_2, and centralization. Each contract allocates formal authority over the decision on transfer price and the quantity to be transferred to the principal or the agent. In the second stage, on observing the principal's choice, the individual with formal authority exercises authority.

The major results show that, in the presence of two agents, when necessary, the principal always allocates the authority to the agent with more valuable private information (greater divisional production cost). The likelihood of full decentralization decreases with the importance of the private information. The principal is more likely to choose decentralization when the production costs of both divisions are relatively low. Conversely, if the production costs are sufficiently high, the principal will choose partial delegation. However, centralization is rarely the best organizational structure, due to the additional constraint of one transfer price. Interestingly, we find that the agent may achieve higher net benefit without the authority over the transfer price.

The above results predict the organizational structure in the real world. The transfer price under all forms is a cost-based markup price, and so both divisions are profit centers.[7] In a survey of Canadian companies that regularly transfer intermediate goods, Shih (1996) showed that 50.7% (67.5%) of companies, with buyer and/or seller profit centers are not wholly owned (wholly owned), set the rules of transfer pricing policy, and 49.3% (32.5%) let their profit centers freely negotiate the transfer price. Of our categories of organizational form, the former falls into the category of centralization or partial delegation, and the latter that of decentralization.[8] Hence, our results will aid the principal to decide how to allocate the authority over the transfer pricing accompanied by the organizational structure.

There are hundreds of studies examining the effects of agency problem, tax, and investment hold-up problem, and product market competition on transfer pricing.[9] Few studies focus on the impact of organizational structure on transfer pricing. Holmstrom and Tirole (1991) was the first one to provide a formal model to connect the relation between transfer pricing and organization design, in a moral hazard setting.[10] Narayanan and Smith (2000) analyzes the impact of product market

[7] Of the Canadian firms that have been surveyed, Tan (1992) and Shih (1996) respectively stated that 46% and 39% adopt a cost-based transfer price, 34% and 48% adopts a market price, and 18% and 13% adopts a negotiated transfer price.

[8] Shih (1996) did not investigate the decision about the quantity of the intermediate goods transferred.

[9] For example, Ronen and McKinney (1970), Groves and Loeb (1979), Harris, Kriebel and Raviv (1982), Ronen and Balachandran (1988), Amershi and Cheng (1990), Banker and Datar (1992), Vaysman (1996), Vaysman (1998), Anctil and Dutta (1999), Hearvner (1998), and Baldenius, Melumad, and Reichelstein (2004) investigated the relationship between transfer pricing and the agency problem under asymmetric information. Stoughton and Talmor (1994), Elitzur and Mintz (1996), and Baldenius, Melumad, and Reichelstein (2004) addressed the association between transfer pricing and tax competition for multi-national firms. Vaysman (1998) adopts mechanism design approach to propose a model of negotiated transfer pricing, while Baldenius, Reichelstein, and Sahay (1999) uses incomplete contracting model to compare the effectiveness of negotiated and cost-based transfer pricing. Edlin and Reishelstein (1995), Anctil and Dutta (1999), Baldenius, Reichelstein, and Sahay (1999), Sansing (1999), and Baldenius (2000) examine the association between relation-specific investment and alternative transfer prices. Baldenius, Melumad, and Reichelstein (2004) analyzes how to integrate managerial and tax objectives in transfer pricing.

[10] They adopted an incomplete contracting approach and constrained the transferred quantity to one unit, in which the Nash bargaining process determines the transfer price, and then compared the cost and benefit of each organizational form.

competition and taxes on transfer prices and responsibility centers. Baiman and Rajan (1995) also examines the issue of organization design in the assignment of capital investment decision rights between one principal and one agent. This study differs from these studies in that our model considers the assignment of decision authorities over the transfer pricing where two agents are subject to adverse selection problem.

This paper is related to studies of organization design. Melumad et.al. (1992) shows that the decentralized responsibility center, where the principal contracts with one center manager and delegates the latter to contract with the other agent, can create the same incentives as centralization, where the principal directly contracts with each agent. They indicate that, for the result to hold, the principal must monitor the measure of financial performance. Baron and Besanko (1992) finds that both centralization and decentralization can produce equivalent performance in a setting where two agents supply strictly complementary inputs and the principal can specify both agents' production levels. Melumad et.al. (1995) shows that the additional incentive problem caused by delegation can be completely resolved, if the principal can monitor the primary contract to the joint product and design the sequence of contracts appropriately. We adapt Melumad et.al. (1995) to address the issue of the transfer pricing with allocation of decision rights in a practical matter.

The rest of this paper is organized as follows. Section 2 describes the model. Section 3 presents a case of benchmark under complete information. Section 4 presents and characterizes the allocation of the decision authority over the transfer price and the quantity to be transferred and the optimal organizational form. Section 5 offers some concluding remarks.

2. The Model

This section presents a model of strategic transfer pricing. Consider a highly automated firm that comprises two systematic divisions: the production division and the marketing division. The firm owner, principal *P*, and two managers of upstream (production) and downstream (marketing) divisions, agents A_1 and A_2, respectively, are all risk-neutral and face the transfer pricing problem. The commodity is produced with two complementary inputs according to the Leontief and one-to-one production technologies. The production division manufactures a highly specialized intermediate product at a cost $C_1(q,\theta_1)=\theta_1 \cdot q$, where $q \in R_+$ is the quantity produced, θ_1 stands for the constant marginal cost of the division in the interval $[\underline{\theta}_1, \overline{\theta}_1]$, and then transfers the product to the marketing division at a transfer price *t*. The marketing division processes the intermediate goods further by adding a special packaging technology at a cost $C_2(q,\theta_2)=\theta_2 \cdot q$, where $\theta_2 \in [\underline{\theta}_2, \overline{\theta}_2]$ is the constant marginal cost. We assume that $C_i(\cdot)$, $i \in \{1,2\}$ is convex and increasing in q and θ_i. The transaction-specific investments of the two divisions are idiosyncratic and nontransferable to any other use, including physical and human capital assets. There is no external market for either the intermediate goods or the special packaging service. The final product monopolizes the market, in which the inverse demand function of the final product is given by $p(q)=a-bq$, $a,b \in R_+$. The marginal net revenue represents reputation factors concerning the market condition, the quality, and the brand name of the product. Hence, these two divisions are in a bilateral monopoly context.[11]

We assume that each agent A_i, $i \in \{1,2\}$, has perfect private information on its marginal cost θ_i prior to contracting. The principal and agent A_j, $j \in \{1,2\}$, $j \neq i$, believe that θ_i is drawn independently from the same common-knowledge distribution $F_i(\theta_i)$ and density $f_i(\theta_i)$ with continuous support $\Theta_i = [\underline{\theta}_i, \overline{\theta}_i]$. Finally,

[11] These two divisions are assumed to be located in the same area and hence adopt same tax rules. This assumption precludes the effect of tax on transfer pricing (Narayanan and Smith, 2000) and the multi-national transfer pricing problem.

after the final products are sold, agent A_i is rewarded by a contract that is linear in the division income $\pi_i(\theta_i)$, plus a fixed payment α_i, that is given by $\omega_i(\theta_i)$ ($\alpha_i + \beta_i \cdot \pi_i(\theta_i)$). We assume that these incentive contract parameters are predetermined prior to contracting.[12] Agent A_i's disutility is associated with the managerial effort e_i that is required to produce q in state θ_i, is not observable by another parties and equals, in monetary terms, $v_i(e_i(\theta_i), q)$, where $v_i(\cdot)$ is increasing and strictly convex in both arguments. Each agent is assumed to have an increasing, differential, and strictly concave von Neumann-Morgenstern utility function $u_i(\theta_i) = \omega_i(\theta_i) - v_i(e_i(\theta_i), q)$, which is additively separable in wealth ω_i and effort e_i. For convenience, let $U_i(\cdot)$ be agent A_i's expected utility and $\Phi_i(\theta_i)$ be the agent's outside opportunity of level of utility that depends on the agent's type of θ_i.

Figure 1 depicts the timeline of the transfer pricing game, which comprises two stages. In the first stage, principal chooses a contract of organizational structure from five feasible structures including centralization *C*, decentralization D_1 or D_2, and partial delegation PD_1 or PD_2. On observing the principal's chosen structure, the individual with formal authority exercises formal authority over transfer price t or quantity to be transferred q. In the second stage, if the principal chooses centralization *C*, then the principal himself proposes the transfer price and quantity to be transferred. If the principal chooses delegation D_i, then agent A_i exercises formal authority over both the transfer price and the quantity to be transferred. Then, the party without formal authority decides whether to accept the transfer price and quantity.[13] If any one party refuses, then the game ends and each agent obtains his type contingent

[12] Linear compensation has been widely used in practice, Holmstrom and Milgrom (1987) demonstrated that, under specific assumptions, linear compensation is optimal. In this paper, incentive parameters α_i and β_i are taken exogenously to be given to preclude the issue of risk sharing. Moreover, all players are assumed to be risk neutral to clarify the adverse selection under incomplete information for simplicity.

[13] Each agent is assumed not to adopt a mixed strategy and to accept the offer when his expected utility is indifferent to accepting or rejecting the offer.

reservation utility. If the principal chooses partial delegation PD_i, then four moves ensue. The principal first proposes the transfer price and then, without loss of generality, agent A_i is assumed to respond by accepting the primary contract and reporting his private information before entering the subcontract.[14] Next, agent A_i proposes the quantity to be transferred and finally agent A_j responds by accepting or rejecting agent A_i's proposal.

[Insert Figure 1 here]

Following Melumad et. al. (1995), the following assumptions are maintained.

Assumption A1. The monotone hazard rate $F_i(\theta_i)/f_i(\theta_i)$ is increasing in θ_i.[15]

Assumption A2. The function $v_i(e_i(\theta_i), q)$ is increasing in $e_i(\cdot)$ and q. The function $\frac{\partial^2 v_i(\theta_i, q)}{\partial\theta_i \partial q}$ is nonnegative and weakly increasing in θ_i.

Assumption A3. $v_i(e_i(\theta_i), q) = e_i(\theta_i) \cdot q$, where e_i is increasing and convex, $e(0) = 0$.

Assumption A4. The incentive contract parameter $\beta_i(\theta_i) \in (0,1]$ is decreasing in θ_i.

The first two assumptions A1 and A2 are standard in the adverse selection models (Guesnerie and Laffont, 1984; Melumad et.al, 1995), which ensure that we solve question of the optimal mechanism by considering only the local incentive compatibility constraints. Assumption A2 is the "single-crossing property". Assumption A3 implies that the cost of effort increase uniformly for higher types. Assumption A4 is standard in models of moral hazard, and indicates that the incentive parameter is decreasing in the divisional constant marginal cost.[16]

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[14] If the agent can delay his decision of acceptance, he may obtain additional private information before contracting with the principal. Additionally, the sequence that the agent reports his cost before subcontracting is to screen his private information and to align his objective with that of the principal. See Melumad et. al. (1995).

[15] Most usual distributions such as uniform, normal, logistic, chi-squared, exponential, and Laplace satisfy this condition. See Laffont and Tirole (1993) for a complete interpretation of this assumption.

[16] Many studies have derived the result under specific conditions, for example, Holmstrom and Milgrom (1991).

3. Benchmark: Complete Information

We first consider the problem with complete information as a case of benchmark.[17] The principal determines whether to retain or delegate the decision authority over the transfer pricing mechanism including the transfer price and quantity to be transferred, i.e. centralization or delegation. Under centralization, the principal chooses the transfer pricing mechanism. Under delegation, the principal delegates the determination of the transfer price to the agent A_1, and then the decision about the quantity to be transferred to agent A_2 to decide. The two agents make decisions by maximizing the principal's expected income.

Proposition 1. *Assume that* $a > \sum_{i=1}^{2} \theta_i$, *under centralization, the quantity to be transferred is* $\frac{1}{2b}(a - \sum_{i=1}^{2} \theta_i)$, *the transfer price is the marginal cost* θ_1, *and the firm's expected profit is* $\frac{1}{4b}(a - \sum_{i=1}^{2} \theta_i)^2$. *Under decentralization, the quantity to be transferred equals* $\frac{1}{4b}(a - \sum_{i=1}^{2} \theta_i)$, *the transfer price is* $\frac{a + \theta_1 - \theta_2}{2}$, *the price of the final product is* $\frac{1}{4}(3a + \sum_{i=1}^{2} \theta_i)$, *and the firm's expected profit is* $\frac{3}{16b}(a - \sum_{i=1}^{2} \theta_i)^2$. *Hence, the principal chooses centralization.*

Proof. All proofs are shown in the appendix.

The assumption of $a > \sum_1^2 \theta_i$ means that the marginal net revenue of the product exceeds the total production costs. Under centralization, the transfer price is the constant marginal cost of the upstream obtained from the first order condition, and hence the production division is a cost center, while the marketing division is a profit center, because of its net profit. Under decentralization, agent A_1 first determines the transfer price, and then agent A_2 chooses the quantity to be transferred. The

[17] Assuming that the marginal costs θ_i of both divisions are public information, and that the principal P can observe the effort e_i of the agents, then there is no need to give an incentive contract.

Stackelberg follower, agent A_2 chooses the quantity to maximize his payment, without taking into account the effect on the company as a whole. The Stackelberg leader A_1, however, also conjectures agent A_2's self-interest behavior, and given that agent A_2's chosen quantity is a function of the transfer price, e.g., $q = q(t)$, responds by choosing the transfer price to maximize his payment. Under this circumstance, the transfer price is greater than the constant marginal production cost θ_1, which leads to double marginalization. The production volume under decentralization is lower than the first best production volume, and thus both divisions are profit centers.

By contrast, centralization avoids double marginalization and demand contraction, and thus the principal prefers a centralized organization structure to a delegated structure. If each division is a separated manufacturer, then we may infer that vertical integration is better for the principal than no integration in the absence of private information. However, this problem depends on the information environment (Tirole, 1988). In the next section, we reconsider the organization design and transfer pricing mechanism in the presence of private information.

4. Allocation of the Decision Authority

Consider a contract that specifies the organizational form and the allocation of decision authority over the decision on the transfer pricing. The contract describes that the principal is credibly committed to exercising the chosen organizational form, and allocates formal authority over the decisions on the transfer price and quantity to be transferred to the principal, agent A_1, or agent A_2, under each governance structure. Each contract of organizational form specifies the transfer pricing mechanism $TP = \{t(\theta_1', \theta_2'), q(\theta_1', \theta_2')\}$ in the feasible set Γ, supposing that *TP* consists of all simultaneous-action mechanisms, including a set of direct revelation mechanisms *tp*. Given the organizational form, the party with authority chooses an acceptable transfer price and quantity to be transferred on the ground of self-interest.

4.1. When the Principal Retains the Authority

The income of the production division π_1 equals the transfer price t minus its cost, C_1. The profit of the marketing division π_2 is the revenue R minus its cost C_2 and the transfer price. The principal's income is the revenue minus the costs of two departments and two agents' expected compensation $\omega_i(\theta_i)$, which is linear in the divisional income π_i, given the fixed payment α_i and the incentive parameter β_i,

$$R(\theta_1,\theta_2)-\sum_{i=1}^{2}C_i(\theta_1,\theta_2)-\sum_{i=1}^{2}[\alpha_i+\beta_i\pi_i(t,\theta_{1,}\theta_2)] \tag{1a}$$

where

$R(\theta_1,\theta_2)=(a-bq(\theta_1,\theta_2))\cdot q(\theta_1,\theta_2)$, $C_i(\theta_1,\theta_2)=\theta_i\cdot q(\theta_1,\theta_2)$,

$\pi_1(\theta_{1,},\theta_2)=t(\theta_{1,},\theta_2)-\theta_1 q(\theta_{1,},\theta_2)$, $\pi_2(\theta_{1,},\theta_2)=R(\theta_{1,},\theta_2)-\theta_2 q(\theta_{1,},\theta_2)-t(\theta_{1,},\theta_2)$.

Substituting these equations into equation (1a) gives the principal's expected income:

$$\begin{aligned}E_{\theta_1\theta_2}\Big\{&\big(a-bq(\theta_1,\theta_2)\big)\cdot q(\theta_1,\theta_2)-\sum_{i=1}^{2}[\theta_i q(\theta_1,\theta_2)+\alpha_i(\theta_i)]-\beta_1(\theta_1)\cdot\big(t(\theta_1,\theta_2)-\theta_1 q(\theta_1,\theta_2)\big)\\&-\beta_2(\theta_2)\cdot\big[\big(a-bq(\theta_1,\theta_2)\big)\cdot q(\theta_1,\theta_2)-\theta_2 q(\theta_1,\theta_2)-t(\theta_1,\theta_2)\big]\Big\}.\end{aligned} \tag{1b}$$

Centralization *C*. Under centralization *C*, the principal chooses the transfer price and quantity to be transferred to maximize the expected income of the firm subject to two agents' truthful revelation of private information (θ_i):

$$\begin{aligned}\text{Program } C:\Pi_c\equiv\underset{t,q}{\text{Max}}\ \mathrm{E}_{\theta_1\theta_2}\Big\{&(a-bq(\theta_1,\theta_2))\cdot q(\theta_1,\theta_2)-\sum_{i=1}^{2}(\theta_i q(\theta_1,\theta_2)+\alpha_i(\theta_i))-\beta_1(\theta_1)(t(\theta_1,\theta_2)\\&-\theta_1 q(\theta_1,\theta_2))-\beta_2(\theta_2)[(a-bq(\theta_1,\theta_2)-\theta_2)q(\theta_1,\theta_2)-t(\theta_1,\theta_2)]\Big\}\end{aligned}$$

subject to: for all $\theta_i,\theta_i'\in\Theta_i$, $i\in\{1,2\}$,

$$\mathrm{E}_{\theta_2}[\alpha_1(\theta_1)+\beta_1(\theta_1)(\mathrm{t}(\theta_1,\theta_2)-\theta_1 q(\theta_1,\theta_2))-e_1(\theta_1)q(\theta_1,\theta_2)]\geq\Phi_1(\theta_1) \tag{2a}$$

$$\mathrm{E}_{\theta_1}\{\alpha_2(\theta_2)+\beta_2(\theta_2)[(a-bq(\theta_1,\theta_2)-\theta_2 q(\theta_1,\theta_2))-t(\theta_1,\theta_2)-e_2(\theta_2)q(\theta_1,\theta_2)]\}\geq\Phi_2(\theta_2) \tag{2b}$$

$$\theta_1 \in \arg\max_{\theta_1'} \mathrm{E}_{\theta_2}\{\alpha_1(\theta_1') + \beta_1(\theta_1')[\mathrm{t}(\theta_1',\theta_2) - \theta_1 q(\theta_1',\theta_2)] - e_1(\theta_1)q(\theta_1',\theta_2)\} \quad (2c)$$

$$\theta_2 \in \arg\max_{\theta_2'} \mathrm{E}_{\theta_1}\{\alpha_2(\theta_2') + \beta_2(\theta_2')[(a - bq(\theta_1,\theta_2') - \theta_2)q(\theta_1,\theta_2') - \mathrm{t}(\theta_1,\theta_2')] - e_2(\theta_2)q(\theta_1,\theta_2')\}. \quad (2d)$$

Equations (2a) and (2b) are the individual rationality (IR) constraints of agent A_1 and agent A_2, respectively. The right-hand side of these equations means that, for any possible state $\theta_i \in \Theta_i$, agent A_i's expected utility is no less than his type contingent reservation utility. The incentive compatibility (IC) constraints of agent A_1 and agent A_2's are equation (2c) and equation (2d), respectively. These equations guarantee that the two agents truthfully reveal the marginal cost is a Bayesian-Nash equilibrium.[18]

Transfer Pricing Mechanism

Studies of mechanism design (for example, Myerson, 1981; Myerson and Satterthwaite, 1983; Mookherjee, and Reichelstein, 1992) provide an approach to characterize this problem. For any possible transfer price or quantity to be transferred that is chosen by the decision maker, given the incentive parameter, the "local" incentive compatibility constraint and individual participation constraint fully determine the compensation that is paid to the agents. We then solve for the optimal transfer pricing mechanism by point-wise maximization or optimal control theory.

Lemma 1. Agent A_i's expected compensation is

$$E_{\theta_1\theta_2}[\omega_i(\theta_i;\theta_j)] = E_{\theta_1\theta_2}\left\{\Phi(\bar{\theta}_i) + e_i(\theta_i)q(\theta_1,\theta_2) + \frac{F_i(\theta_i)}{f_i(\theta_i)}[(\beta_i(\theta_i) + e_i'(\theta_i))q(\theta_1,\theta_2) - \Phi(\bar{\theta}_i)]\right\}$$

$$\equiv E_{\theta_1\theta_2}[h_i(q(\theta_1;\theta_2),\theta_i)].\, i, j \in \{1,2\},\ i \neq j.$$

Following Myerson (1981), we refer to $h_i(q(\theta_1,\theta_2),\theta_i)$ as agent A_i's virtual cost, which includes not only A_i's cost of effort, ($e_i q$) and informational cost of preventing

[18] We assume that the expected utility functions of the agents are concave and meet the conditions, so that the problem can be solved by the first-order approach, see Rogerson (1985) and Jewitt (1988) for more details. Under specific circumstance, if the principal replaces the Bayesian incentive-compatible constraints by imposing truthful reporting as a dominant strategy, then, under specific conditions, the principal's expected income will not change (Mookherjee and Reichelstein, 1992).

A_i from dishonestly reporting θ_i,($(F_i / f_i)\cdot(\beta_i + e_i')q$), but also A_i's type contingent reservation utility, (Φ_i). For simplicity, the reservation utility of each agent is normalized to zero in the following analysis.

Proposition 2.

(i) Under centralization C, the expected quantity to be transferred is

$$\frac{1}{2b}E_{\theta_1\theta_2}\left\{a-\sum_{i=1}^{2}\left[\theta_i+\frac{e_i(\theta_i)}{\beta_i(\theta_i)}+\frac{F_i(\theta_i)}{f_i(\theta_i)}\left(1+\frac{e_i'(\theta_i)}{\beta_i(\theta_i)}\right)\right]+\sqrt{\left\{a-\sum_{i=1}^{2}\left[\theta_i+\frac{e_i(\theta_i)}{\beta_i(\theta_i)}+\frac{F_i(\theta_i)}{f_i(\theta_i)}\left(1+\frac{e_i'(\theta_i)}{\beta_i(\theta_i)}\right)\right]\right\}^2+4b\sum_{i=1}^{2}\frac{\alpha_i}{\beta_i}}\right\}\equiv Q_c.$$

(ii) Under centralization C, if the principal adopts dual pricing, then the expected quantity to be transferred is

$$E_{\theta_1\theta_2}[q(\theta_1,\theta_2)]=\frac{1}{2b}E_{\theta_1\theta_2}\left\{a-\sum_{i=1}^{2}\left[\theta_i+e_i(\theta_i)+\frac{F_i(\theta_i)}{f_i(\theta_i)}(\beta_i(\theta_i)+e_i'(\theta_i))\right]\right\}\equiv Q_{cd}(\theta_1,\theta_2).$$

(iii) The expected transfer price under centralization C is such that

$E_{\theta_1\theta_2}[t(\theta_1,\theta_2),q]=T_1(Q_c,\theta_1,\theta_2)=T_2(Q_c,\theta_1,\theta_2)\equiv T_c(Q_c,\theta_1,\theta_2)$*, where E(q)is* Q_c.

$$T_1=E_{\theta_1\theta_2}\left\{(a-bq(\theta_1,\theta_2)-\theta_2)q(\theta_1,\theta_2)-\frac{h_2(q(\cdot),\theta_2)-\alpha_2(\theta_2)}{\beta_2(\theta_2)}\right\},$$

$$T_2=E_{\theta_1\theta_2}\left[\theta_1 q(\theta_1,\theta_2)+\frac{h_1(q(\cdot),\theta_1)-\alpha_1(\theta_1)}{\beta_1(\theta_1)}\right]$$

(iv) If the principal adopts dual pricing, then the expected transfer price of the production division and the marketing division is $T_2(q(\cdot),\theta_1,\theta_2)$ *and* $T_1(q(\cdot),\theta_1,\theta_2)$*, respectively.*

According to Lemma 1, the transfer price is obtained by equating A_i's expected compensation $\omega_i(t)$, which is a function of the transfer price, and his virtual cost $h_i(q,\theta_i)$, when only one agent's incentive is considered such as under decentralization i.e., $t=\omega_i^{-1}(h_i(q))$ ($\omega_i(t)=h_i(q,\theta_i)$), i=1 or 2. By contrast, under centralization, the principal has to simultaneously balance the incentives of the two agents and consider the two agents' informational costs as well as cost of effort, which are represented by their IR and IC constraints. He must choose a transfer price such that it simultaneously satisfy these constraints, i.e., $\omega_i(t) = h_i(q, \theta_i)$, i=1 and 2. This additional constraint restricts the choice of the quantity to be transferred, i.e., $t = \omega_1^{-1}(h_1(q)) = \omega_2^{-1}(h_2(q))$, without taking into account the principal's objective of profit maximization, under the assumption of the linear inverse demand function. As a result, it is difficult for the principal to concurrently account for both information revelation and profit objective under asymmetric information. The above results indicate that the transfer price in the context of one-principal-two-agents differs from that of one-principal-one-agent, and hence Esscles (1985)'s conjecture is demonstrated. Under centralization, the transfer price in a one-principal-one-agent model is more similar to one of the dual price in the one-principal-two-agents model.

By contrast, the dual price allows the principal separately trade off the incentive problem of each agent and his objective,[19] and eliminates the constraint of a single transfer price. The transfer price of the production division T_2 is independent of the marketing division, T_1. In this case, the quantity to be transferred is the marginal net revenue a net of the production cost of both divisions ($\sum \theta_i$), cost of effort of the two agents ($\sum e_i / \beta_i$), and the informational cost of preventing each agent from dishonestly reporting his cost of production, $(F_i / f_i) \cdot (\beta_i + e_i')$.

4.2. When the Principal Fully Delegates the Authority

When the principal delegates the decision authority over transfer pricing to the agent, he only contracts with agent A_1 or A_2 and authorizes the agent to exercise authority over the transfer pricing decision. We consider the following two regimes:

Decentralization D_1**.** Agent A_1 proposes both the transfer price t and the quantity to

[19] The dual price means that in accounting, the transfer price that the upper division receives differs from the price paid by the downstream division, so there are two kinds of transfer prices.

be transferred q to maximize his expected utility U_1, subject to agent A_2's truthfully revelation of his private information:

Program $D_1 : \underset{t(\cdot),q(\cdot)}{\text{Max}} \quad E_{\theta_2}\{\ \alpha_1(\theta_1)+\beta_1(\theta_1)[t(\theta_1,\theta_2) - \theta_1 q(\theta_1,\theta_2)] - e_1(\theta_1)q(\theta_1,\theta_2)\ \}$

subject to: for all $\theta_2 \in \Theta_2$,

$$\alpha_2(\theta_2)+\beta_2(\theta_2)[(a-bq(\theta_1,\theta_2)-\theta_2)q(\theta_1,\theta_2)-t(\theta_1,\theta_2)]-e_2(\theta_2)q(\theta_1,\theta_2) \geq \Phi_2(\theta_2) \quad (6a)$$

$$\theta_2 \in \arg\max_{\theta_2'} \{\alpha_2(\theta_2')+\beta_2(\theta_2')[(a-bq(\theta_1,\theta_2')-\theta_2)q(\theta_1,\theta_2')-t(\theta_1,\theta_2')]-e_2(\theta_2)q(\theta_1,\theta_2')\}. \quad (6b)$$

Equations (6a) and (6b) are the *IR* and *IC* constraints of agent A_2.[20]

Decentralization D_2. Similarly, under this regime, agent A_2 proposes both the transfer price t and the quantity to be transferred q to maximize his expected income as the expected value of the left-hand-side of equation (6a).

Proposition 3.

(i) Under decentralization $D_i, i, j \in \{1,2\}, i \neq j$, the expected quantity to be transferred is $E_{\theta_1\theta_2}[q(\theta_1,\theta_2)] = \frac{1}{2b} E_{\theta_1\theta_2}\left\{a - \sum_{i=1}^{2}\left(\theta_i + \frac{e_i(\theta_i)}{\beta_i(\theta_i)}\right) - \frac{F_j(\theta_j)}{f_j(\theta_j)}\cdot\left(1+\frac{e_j'(\theta_j)}{\beta_j(\theta_j)}\right)\right\} \equiv Q_i(\theta_1,\theta_2)$.

(ii) The expected transfer price under decentralization D_1 is T_1.

(iii) The expected transfer price under decentralization D_2 is T_2.

Under decentralization D_i, the quantity to be transferred is the marginal net revenue a net of the production cost of both divisions ($\sum \theta_i$), cost of effort of the two agents ($\sum e_i/\beta_i$), and the informational cost of preventing the agent A_j from dishonestly reporting his production cost $(F_j/f_j)\cdot(1+(e_j'/\beta_j))$. Additionally, Proposition 3(i) indicates that the quantity chosen by different agents is only affected by the differential cost of information. A higher level of informational cost reduces the

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[20] We assume, without loss of generality, that the principal accepts the transfer pricing mechanism that is designed by agent A_i under decentralization D_i. We will check whether the principal's expected profit is positive later after the optimal solutions have been obtained, assuming that the principal's reservation utility is normalized to zero.

quantity to be chosen. Finally, compared to the scenario of complete information, the quantity to be transferred under incomplete information is lower than the first best quantity due to the additional cost comprised by cost of effort and informational cost, but the same level of marginal net revenue.

The expected transfer price T_2 under decentralization D_2 is a cost-based transfer price in which the costs are marked up by agent A_1's virtual cost net of his fixed payment, with the markup ratio of A_1's incentive contract parameter $1/\beta_1$. Under decentralization D_1, the transfer price T_1 is close to the concept of cost reimbursement. The cost reimbursement rule is to reimburse agent A_2's virtual cost net of his fixed payment, with the markup ratio is agent A_2's incentive contract parameter $1/\beta_2$. This result is consistent with the discussion of section 5.1 in Holmstrom and Tirole (1991), in the corrupted-M form of which the principal constrains internal trading.[21] Note that the agent with authority always chooses a transfer price such that the net realizable value is assign to its division, which will be explained in the next section.

4.3. When the Principal Partially Delegates the Decision Authority

Partial delegation PD_1. Under this structure, there is a three-tier hierarchy in the firm. The principal only contracts with agent A_1 and delegates this agent to sign a subcontract with agent A_2. Given that the principal chooses partial delegation PD_1 in the first stage, the principal offers a menu of contracts with the form $\{t(\theta_1,\theta_2)\}$ that is acceptable to agent A_1 in the second stage. For any value of divisional constant marginal cost that is reported by agent A_1 (θ_1'), A_1 with private information θ_1 designs the following contract of the quantity to be transferred for agent A_2:

[21] Our regimes of decentralization and partial delegation are equivalent to their corrupted-M form, except that in our model the quantity is endogenous. In our model, the production cost C_i is incurred only if the internal transaction takes place. This cost increases in proportion to the quantity to be transferred, which brings an outside option for the divisional manager, as if the manager does not agree with this mechanism, then the internal trade will not occur and then the division may avoid the cost C_i (Holmstrom and Tirole, 1991). Therefore, this transfer price is affected by the cost of the division without decision authority and results in a cost-based markup transfer price.

$$\mathrm{PD}_{1\_\mathrm{sub}} : \Gamma_1(\theta_1 | q(\theta_1, \theta_1')) \equiv \underset{q(\cdot)}{\mathrm{Max}} \, \mathrm{E}_{\theta_2} \{\alpha_1(\theta_1) + \beta_1(\theta_1)[\mathrm{t}(\theta_2 | \theta_1, \theta_1') - \theta_1 q(\theta_2 | \theta_1, \theta_1')] - e_1(\theta_1) q(\theta_2 | \theta_1, \theta_1')\} \quad (3)$$

subject to: for all $\theta_2 \in \Theta_2$ and all $\theta_1, \theta_1' \in \Theta_1$,

$$\alpha_2(\theta_2) + \beta_2(\theta_2)\{[a - bq(\theta_2 | \theta_1, \theta_1') - \theta_2] q(\theta_2 | \theta_1, \theta_1') - \mathrm{t}(\theta_2 | \theta_1, \theta_1')\} - e_2(\theta_2) q(\theta_2 | \theta_1, \theta_1') \geq \Phi_2(\theta_2) \quad (4a)$$

$$\theta_2 \in \arg\max_{\theta_2'} \alpha_2(\theta_2') + \beta_2(\theta_2')\{[a - bq(\theta_2' | \theta_1, \theta_1') - \theta_2] q(\theta_2' | \theta_1, \theta_1') - \mathrm{t}(\theta_2' | \theta_1, \theta_1')\} - e_2(\theta_2) q(\theta_2' | \theta_1, \theta_1'). \quad (4b)$$

Equations (4a) and (4b) represent the *IR* and *IC* constraints of agent A_2, respectively. Let $\Gamma_1(\theta_2 | q(\theta_1, \theta_1'))$ be the value of the optimization program PD_{1_sub} and represent agent A_1's reduced-form of utility function. Given the transferred quantity $q(\cdot)$ that is chosen by agent A_1, the principal's problem in the second stage is then

$$PD_1 : \Pi_{\mathrm{PD}_1} \equiv \underset{t}{\mathrm{Max}} \; E_{\theta_1\theta_2} \left\{ [a - bq(\theta_1, \theta_2) - \sum_{i=1}^{2} \theta_i] q(\theta_1, \theta_2) - \sum_{i=1}^{2} \alpha_i(\theta_i) - \beta_1(\theta_1)(t(\theta_1, \theta_2) - \theta_1 q(\theta_1, \theta_2))] \right.$$
$$\left. - \beta_2(\theta_2)\{[a - bq(\theta_1, \theta_2) - \theta_2] q(\theta_1, \theta_2) - t(\theta_1, \theta_2)\} \right\}$$

subject to: for all $\theta_1 \in \Theta_1$,

$$\Gamma_1(\theta_1 | q(\theta_1, \theta_1')) \geq \Phi_1(\theta_1), \quad (5a)$$

$$\theta_1 \in \arg\max_{\theta_1'} \; \Gamma_1(\theta_1 | q(\theta_1, \theta_1')), \quad (5b)$$

there exists $\{q(\theta_2 | \theta_1, \theta_1)\} \in \arg\max PD_{1\_sub}$, such that $q(\theta_1, \theta_2) \equiv q(\theta_2 | \theta_1, \theta_1)$, for all θ_2. (5c)

Equations (5a) and (5b) are the *IR* and *IC* constraints of agent A_1 under the agent's own reduced-form of utility function, respectively. Equation (5c) represents that, given agent A_1's chosen quantity to be transferred, agent A_2's best response is to truthfully report his private information θ_2, and so $q(\theta_2 | \theta_1, \theta_1') = q(\theta_2 | \theta_1, \theta_1) \equiv q(\theta_1, \theta_2)$. Similarly, the transfer price chosen by the principal is such that agent A_1's best response is to honestly report his private information θ_1, and hence $t(\theta_2 | \theta_1, \theta_1') = t(\theta_2 | \theta_1, \theta_1) \equiv t(\theta_1, \theta_2)$.

Partial delegation PD_2**.** Under this regime**,** the principal first chooses an acceptable transfer price and contracts with agent A_2 for the authority to determine the quantity. Then agent A_2 makes a take-it-or-leave-it offer of the quantity to agent A_1.

Proposition 4.

(i) Under partial delegation PD_i, $i, j \in \{1,2\}, i \neq j$, the expected quantity to be transferred is $Q_i(\theta_1, \theta_2)$.

(ii). The expected transfer price under partial delegation PD_2 is $T_1(q)$.

(iii) The expected transfer price under partial delegation PD_1 is $T_2(q)$.

The agent A_i chooses the same quantity under D_i and PD_i, as a result of the same objective function that maximizes A_i's expected utility subject to A_j's *IR* and *IC* constraints. Agent A_i trades off his compensation objective against the informational cost of making A_j truthfully declare θ_j. Similarly, the functional form of the expected transfer price that is chosen by agent A_i under decentralization D_i is the same as that chosen by the principal under partial delegation PD_j as a result of the same incentive constraints of agent A_j. These transfer prices are all cost-based markup price.

Substituting the transfer price into the objective function of division *i* and *j*, under decentralization D_i and partial delegation PD_j, and rearranging terms yield the expected profit of division *i* is

$$E_{\theta_i\theta_j}\left[\pi_i(\cdot)\right] = E_{\theta_i\theta_j}\left[(a - bq(\theta_1,\theta_2)) \cdot q(\theta_1,\theta_2) - \sum_{i=1}^{2} \theta_i q(\theta_1,\theta_2) - \frac{h_j(q(\cdot),\theta_j) - \alpha_j(\theta_j)}{\beta_j(\theta_j)}\right],$$

and the expected profit of division *j* is

$$E_{\theta_i\theta_j}\left[\pi_j(\cdot)\right] = E_{\theta_i\theta_j}\left[\frac{h_j(q(\cdot),\theta_j) - \alpha_j(\theta_j)}{\beta_j(\theta_j)}\right],$$

where *E(q)* is Q_i under D_i and Q_j under PD_j. Hence, both divisions are profit centers, which is consistent with widespread existing practice. The above two equations also indicate that, under decentralization, the agent with authority over transfer price would choose a price to subsidize the other division the amount of its agent's virtual cost and keep all of the remaining profit in his division. The remaining profit is equal to the net realizable value excluding the virtual cost of the final goods.

Whether it is beneficial for so doing depends on the inverse demand function. Given a level of the quantity, the divisional income with T_i will be greater than with T_j, if the net marginal revenue is sufficiently enough. However, these results will be opposite under partial delegation. Under partial delegation PD_j, while balancing two agents' incentive to honestly reveal information, the principal let A_j to decide the quantity and chooses the transfer price T_i. The price chosen is such that division j is reimbursed the virtual cost and that the division i, without decision right, obtains the remaining profit. Nevertheless, it is not always beneficial for division i, under D_i or PD_j, to be assigned the net realizable value.

Corollary 1.

Under decentralization and partial delegation, both divisions are profit centers.

4.4. When and to Whom Should the Principal Delegate?

We first compare the principal's preference of any two organizational forms and then summarize the principal's optimal choice. The difference of the principal's income under D_i, $\Pi(T_i,Q_i)$, and PD_j, $\Pi(T_i,Q_j)$, with the same transfer price, is determined by the quantity. Recall that the quantity chosen by one agent is negatively influenced by the informational costs of preventing the other agent from dishonestly reporting his private information of production cost. The difference of the quantity under these two forms is:

$$Q_i - Q_j = \frac{1}{2b} E_{\theta_1\theta_2}\left\{ \frac{F_i(\theta_i)}{f_i(\theta_i)} \cdot \left(1 + \frac{e_i'(\theta_i)}{\beta_i(\theta_i)}\right) - \frac{F_j(\theta_j)}{f_j(\theta_j)} \cdot \left(1 + \frac{e_j'(\theta_j)}{\beta_j(\theta_j)}\right) \right\}$$

The first term and the second term are respectively the informational costs borne by A_j, under PD_j, and *by* A_i, under D_i. Given assumption A1, the larger the cost of production, the greater is the cost of information.

Therefore, when the expected marginal cost of the division *i* is larger than that of the division *j*, compared to agent A_i, A_j bears more informational cost and chooses a lower level of quantity*:* $Q_j<Q_i$. Moreover, under D_i and PD_j, Figure 2 shows that the principal's expected income $\Pi(T_i,Q)$ is increasing and concave in Q, where $Q_j < Q_i < \hat{Q}_i$ and $\hat{Q}_i$ is obtained by differentiating $\Pi(T_i,Q)$ with respect to Q. The quantity $\hat{Q}_i$ achieves the largest expected income of the principal when θ_j is public information. Hence, the principal's expected income under D_i ($\Pi(T_i,Q_i)$) is greater than that under PD_j, $\Pi(T_i,Q_j)$. Likewise, the principal prefers PD_i ($\Pi(T_j,Q_i)$) to D_j ($\Pi(T_j,Q_j)$), because the principal's expected income under these two forms is $\Pi(T_j,Q)$, which is increasing and concave in Q, where as $Q_j < Q_i < \hat{Q}_j$.

[Insert Figure 2 here]

Lemma 2. *(Comparison of decentralization D_i and partial delegation PD_j)*

When the production cost of department i is greater than that of department j, the principal prefers decentralization D_i to partial delegation PD_j, and partial delegation PD_i to decentralization D_j. $i, j \in \{1,2\}, i \neq j$. $(E(\theta_i) > E(\theta_j)$, $\Pi_{D_i} > \Pi_{PD_j}$ *and* $\Pi_{PD_i} > \Pi_{D_j}$)

To facilitate the comparison of the organizational forms, we make four conditions in the following analysis, which is shown in the appendix. Now compare the principal's preference over D_i and PD_i. The principal's expected income under D_1 is $\Pi(T_1,Q_1)$ and $\Pi(T_2,Q_1)$ under PD_1. Given the expected quantity Q, the difference in the principal's expected income under these two structures is

$$\Pi(T_1, Q_1) - \Pi(T_2, Q_1) = E_{\theta_1\theta_2}\left[(\beta_2(\theta_2) - \beta_1(\theta_1))(T_1(\cdot) - T_2(\cdot))\right] .$$

From Proposition 1, we know that, under centralization, T_1 equals T_2 and that the quantity chosen is Q_c. Let $T_1(\cdot) - T_2(\cdot)$ be $\Delta T(\cdot)$, which is depicted in Figure 3. The function ΔT is decreasing and concave in Q, if $Q > Q_0$, where Q_0 is obtained from differentiating ΔT with respect to Q. Direct calculations give that $Q_1 < Q_c$, if C1 holds, and that both Q_c and Q_1 are greater than Q_0. Moreover, according to Assumption A4, the incentive contract parameter β is decreasing in production cost θ. Therefore, when E(θ_1) is greater than E(θ_2), the principal prefers decentralization D_1 to partial delegation PD_1, if condition C1 holds. Likewise, the principal prefers PD_1 to D_1, when E(θ_1) is lower than E(θ_2). In sum, when the expected marginal cost of the production division is larger than that of the marketing division, the principal prefers decentralization D_1 to partial delegation PD_1 if condition C1 holds, and PD_1 to D_1, under condition C1'. These results hold for D_2 and PD_2 under condition C2 and C2'.

[Insert Figure 3 here]

Lemma 3. *(Comparison of decentralization D_i and partial delegation PD_i)*

(i) When the production cost of production department is greater than that of marketing department, the principal prefers decentralization D_1 to partial delegation PD_1 under condition C1, and partial delegation PD_1 to decentralization D_1 under condition C1'. (When $E(\theta_1) \gtrless E(\theta_2)$, $\Pi_{D_1} \gtrless \Pi_{PD_1}$ if condition C1 holds; and conversely, $\Pi_{D_1} \lessgtr \Pi_{PD_1}$ if condition C1' holds.)

(ii) When the production cost of production department is smaller than that of marketing department, the principal prefers decentralization D_2 to partial delegation PD_2 under condition C2, and partial delegation PD_2 to decentralization D_2 under condition C2'. (When $E(\theta_1) \lessgtr E(\theta_2)$, $\Pi_{D_2} \gtrless \Pi_{PD_2}$ if condition C2 holds; and conversely, $\Pi_{D_2} \lessgtr \Pi_{PD_2}$ if condition C2' holds.)

The above results indicate that the principal always delegates the authority to the agent whose divisional production cost is greater and bears lower informational cost, and hence who possesses more valuable private information. The sequence of the expected profit under all organizational forms except centralization and conditions are summarized in Table 1. Note that conditions C1 and C2' when $E(\theta_1) > E(\theta_2)$, and C1' and C2 when $E(\theta_1) < E(\theta_2)$, do not concurrently hold. Conditions C1, C1', C2, and/or C2', and the above results give the principal's preference in delegating authority as follows.

[Insert Table 1 here]

Corollary 2. *(Comparison of decentralization and partial delegation)*

The principal's preference in decentralization and partial delegation is as follows.

(i) If $E(\theta_1) > E(\theta_2)$, the principal chooses decentralization D_1, if condition C1 holds, or partial delegation PD_1, if C1' holds.

(ii) If $E(\theta_1) < E(\theta_2)$, then the principal chooses decentralization D_2 if condition C2 holds, or partial delegation PD_2, if C2' holds.

The principal's optimal choice of the organizational form, except for centralization, is depicted in Figure 4, where "oe" is the 45° line, dot "ce" is the intersection of the 45° and horizontal line θ_1. Dot "de" is the intersection of the 45° line and the vertical line θ_2. The principal's optimal choice is decentralization in area "oce" and area "ode." In area "cfhe," where θ_1 is expected to be greater than θ_2, the principal's optimal choice is partial delegation PD_1. In the area of "dghe", where θ_2 is expected to be greater than θ_1, the principal chooses partial delegation PD_2 and delegates the quantity decision to agent A_1. When θ_1 and θ_2 are relatively small or the marginal net revenue exceeds a threshold (C1 or C2 holds), the principal tends to choose decentralization. By contrast, when θ_1 and θ_2 are relatively large or the marginal net revenue falls below the threshold (C1' or C2' holds), the principal is inclined to choose partial delegation. The conditions C3 and C4 are to facilitate the comparison of centralization and other organizational forms and are shown in the Appendix.

[Insert Figure 4 here]

Lemma 4. (Comparison of C, D_1, and D_2)

(i) The principal prefers D_1 to C, if C3 or C1' holds. If C3' and C1 hold, then the principal prefers C to D_1,

(ii) The principal prefers D_2 to C if C4 or C2' holds. If C4' and C2 hold, then the principal prefers C to D_2.

Lemma 5 (Comparison of C, PD_1, and PD_2)

(i) If $E(\theta_1) > E(\theta_2)$, then the principal prefers PD_1 to C if C4 or C1' holds. If C4' and C1 hold, then the principal prefers C to PD_1. Moreover, the principal prefers PD_2 to C if C3 holds and $Q_c > Q'_{2,1}$, or if C2' holds. If C3 holds and $Q_c \in (Q'_1, Q'_{2,1})$, or if C3' and C2 hold, then the principal prefers C to PD_2, where

$$Q'_1(\theta_1,\theta_2) = \frac{1}{2b} E_{\theta_1\theta_2}\left\{a - \sum_{i=1}^{2}\theta_i + \frac{e_1(\theta_1)}{\beta_1(\theta_1)} + \frac{1-2\beta_2(\theta_2)+\beta_1(\theta_1)}{(1-\beta_1(\theta_1))}\cdot\left[\frac{e_2(\theta_2)}{\beta_2(\theta_2)} + \frac{F_2(\theta_2)}{f_2(\theta_2)}\cdot\left(1+\frac{e'_2(\theta_2)}{\beta_2(\theta_2)}\right)\right]\right\}$$

$$Q'_{2,1} = \frac{1}{2b} E_{\theta_1\theta_2}\left[a - \sum_{i=1}^{2}\theta_i + \frac{e_1(\theta_1)}{\beta_1(\theta_1)} + \frac{1+\beta_1(\theta_1)-2\beta_2(\theta_2)}{(1-\beta_1(\theta_1))}\cdot\frac{e_2(\theta_2)}{\beta_2(\theta_2)} + \frac{F_1(\theta_1)}{f_1(\theta_1)}\cdot\left(1+\frac{e'_1(\theta_1)}{\beta_1(\theta_1)}\right) - \frac{2(\beta_2(\theta_2)-\beta_1(\theta_1))}{1-\beta_1(\theta_1)}\cdot\frac{F_2(\theta_2)}{f_2(\theta_2)}\cdot\left(1+\frac{e'_2(\theta_2)}{\beta_2(\theta_2)}\right)\right].$$

(ii) If $E(\theta_1) < E(\theta_2)$, then the principal prefers PD_2 to C if C3 or C2' holds, or if C2, C3' hold, and $Q_c \in (Q'_{2,1}, Q'_1)$. If C3' and C2 hold, for $Q_c \in (Q_2, Q'_{2,1})$, *then the principal prefers C to PD_2. Moreover, the principal prefers PD_1 to C if C4 holds and $Q_c > Q'_{1,2}$, or if C1' holds. If C4 holds and $Q_c \in (Q'_2, Q'_{1,2})$, or if C4' and C1 hold, then the principal prefers C to PD_1, where*

$$Q_2'(\theta_1,\theta_2)=\frac{1}{2b}E_{\theta_1\theta_2}\left\{a-\sum_{i=1}^{2}\theta_i+\frac{e_2(\theta_2)}{\beta_2(\theta_2)}+\frac{1-2\beta_1(\theta_1)+\beta_2(\theta_2)}{(1-\beta_2(\theta_2))}\cdot\left[\frac{e_1(\theta_1)}{\beta_1(\theta_1)}+\frac{F_1(\theta_1)}{f_1(\theta_1)}\cdot\left(1+\frac{e_1'(\theta_1)}{\beta_1(\theta_1)}\right)\right]\right\}$$

$$Q_{1,2}'=\frac{1}{2b}E_{\theta_1\theta_2}\left[a-\sum_{i=1}^{2}\theta_i+\frac{1-2\beta_1(\theta_1)+\beta_2(\theta_2)}{1-\beta_2(\theta_2)}\cdot\frac{e_1(\theta_1)}{\beta_1(\theta_1)}+\frac{e_2(\theta_2)}{\beta_2(\theta_2)}-\frac{2(\beta_1(\theta_1)-\beta_2(\theta_2))}{1-\beta_2(\theta_2)}\cdot\frac{F_1(\theta_1)}{f_1(\theta_1)}\cdot\right.$$
$$\left.\left(1+\frac{e_1'(\theta_1)}{\beta_1(\theta_1)}\right)+\frac{F_2(\theta_2)}{f_2(\theta_2)}\left(1+\frac{e_2'(\theta_2)}{\beta_2(\theta_2)}\right)\right].$$

The principal's preference under all feasible organizational forms in terms of his expected income is shown in the following. The sequence of the expected profit under all organizational forms and conditions is summarized in Table 3. We now present the perfect Bayesian equilibrium including the principal's optimal choice of organizational structure and transfer pricing mechanism.

[Insert Table 2 here]

Proposition 5. *Assume that* $E(\theta_1) > E(\theta_2)$,

(i) the principal chooses partial delegation PD_1 *if conditions C1', C3', and C4' hold, and hence the perfect Bayesian equilibrium is {*PD_1,T_2, Q_1, A_1 *accepts* T_2 *and* Q_1 , A_2 *accepts* Q_1*},*

(ii) the principal chooses decentralization D_1 *if conditions C1, C2, C3, and C4 hold, and hence the perfect Bayesian equilibrium is {*D_1, T_1,Q_1, A_2 *accepts* T_1 *and* Q_1*}.*

The chosen organizational form is also agent A_1's preferred structure, and hence achieves goal congruence. Agent A_1's chosen quantity Q_1 is also the maximum quantity among all of the feasible organizational forms. If the principal chooses partial delegation PD_2, delegation D_2, or centralization *C*, then the informational cost is greater and leads to underproduction. Condition C1' represents the situation in which the marginal net revenue of the final product *a* is less than the expected total costs including the constant marginal cost θ_i of the two divisions, cost of effort of the agents, and the marginal informational cost. When the difference of both types exceeds a specific range and θ_1 is relatively large than θ_2, the likelihood that condition C1' will hold increases. By contrast, when the expected constant marginal cost of the production division is less than that of the marketing division, the principal chooses partial delegation PD_2 or decentralization D_2, as shown in the following.

Proposition 6. *When* $E(\theta_1) < E(\theta_2)$,

(i) the principal chooses partial delegation PD_2 *if conditions C2', C3', and C4' hold, and hence the perfect Bayesian equilibrium is {*PD_2*,* T_1*,* A_2 *accepts* T_1*,* Q_2*,* A_1 *accepts* Q_2*},*

(ii) the principal chooses partial delegation D_2 *if conditions C1, C2, C3, and C4 hold, and hence the perfect Bayesian equilibrium is {*D_2*,*T_2*,* A_1 *accepts* T_2 *and* Q_2*}.*

The above results show that the principal always allocates the authority to the agent whose divisional production cost is greater and hence more valuable. The principal is more likely to choose decentralization D_1 or D_2, if the marginal costs of both divisions are small and the marginal net revenue is higher than a threshold (C1 or C2). The threshold is comprised by the marginal production costs of two divisions, the cost of effort of the agents, and the informational cost of preventing the agents from dishonestly reporting the private information. Conversely, if the production costs are relatively large, and the marginal net revenue is lower than the threshold (C1' or C2'), then the principal is more likely to choose partial delegation PD_1 or PD_2.

Additionally, in contrast to the decision of the production volume, the determination of the transfer price is a long-term decision and is of great importance. Hence, if the principal chooses partial delegation PD_i, then in the beginning he offers a menu of transfer price that may be acceptable to the divisional manager A_i, and then assigns agent A_i the formal authority over the decision on the quantity to be transferred. In the following periods, agent A_i adjusts the proposed quantity with regard to changes in the market conditions and production technology. In the scenario of a three-tier hierarchy, centralization is rarely the best organizational form, as only one single quantity to be transferred satisfies the constraints of the incentives of both agents and one single transfer price, which generally does not maximize the principal's expected income.

Proposition 7. *The principal chooses centralization C if conditions C1, C2, C3' and C4' hold, and hence the perfect Bayesian equilibrium is {C, T_c, Q_c, A_1 and A_2 accept T_c and Q_c}.*

The principal's optimal choice of the organizational form is depicted in Figure 6, which is similar to Figure 5, except two lines, "ik" and "jk". In area "cfhe," where θ_1 is expected to greater than θ_2, the principal's optimal choice is partial delegation PD_1. In area "dghe", the principal chooses partial delegation PD_2. In area "oik" and "ojk", the principal still chooses decentralization, but, in areas "icek" and "jdek" the principal chooses centralization.

[Insert Figure 5 here]

The above results indicate that each organizational structure may be the principal's best choice, depending on the marginal net revenue, the difference between the production costs of the two divisions, the cost of effort of the two agents, and the marginal informational cost. In sum, the principal chooses organizational form with varying degrees of decentralization by allocating formal authority over transfer pricing. This management control system may be incentive compatible and then motivate agent to exert effort in a cost-effective manner. These results partially explain organizational forms in the real world. In general, a firm's size is positively related to its constant marginal cost, and hence the need for the separation of authority increases and the principal is more likely to choose delegation or partial delegation. If the marginal cost is of great importance, then the principal chooses partial delegation.

4.5 Discussion: Allocation of Authority

The above results indicate that the principal allocates the decision authority over transfer price and quantity to the agent or himself depending on the relative important of the private information of each agent. The party exercises his formal authority on account of his interest. However, holding more authority is not always favorable for the agent. For instance, Proposition 4(i) shows that, when the margin constant cost of the production department is greater, the principal chooses partial delegation PD_1 if conditions C1', C3', and C4' hold. The agent A_1 also prefers this organizational form than decentralization D_1, though he only has the authority over the quantity to be transferred. Hence the possession of formal authority over the decision on the transfer price is not definitely favorable for agent A_1. However, in this case, agent A_2 prefers delegation D_1 to partial delegation PD_1 and delegation D_2 to delegation PD_1. Therefore, delegating the formal authority over the decision on the transfer pricing mechanism to A_2 will result in dysfunctional behavior. Likewise, the above results hold for agent A_2, if condition C2' holds.

Consequently, the principal may effectively control the agents and motivate their efforts by an appropriate organization design and allocation of formal authority over the decisions on the transfer price and the quantity to be transferred. The possession of more formal authority is not surely advantageous to the agent: under certain conditions, not possessing formal authority may be a best in his interests. These results are summarized in the following Corollary.

Corollary 3

(i) When $E(\theta_1) > E(\theta_2)$, $U_{1,D_1} > U_{1,PD_1}$, $U_{2,D_1} < U_{2,PD_1}$ *if condition C1 holds, and*

$U_{1,D_1} < U_{1,PD_1}$, $U_{2,D_1} > U_{2,PD_1}$ *if condition C1' holds, where* $U_{i,j}$ *is agent* A_i*'s expected utility under organizational form* j *.*

(ii) When $E(\theta_1) < E(\theta_2)$, $U_{2,D_2} > U_{2,PD_2}$, $U_{1,D_2} < U_{1,PD_2}$ *if condition C2 holds, and*

$U_{2,D_2} < U_{2,PD_2}$, $U_{1,D_2} > U_{1,PD_2}$ *if condition C2' holds.*

5. Concluding Remarks

Organizational structure determines how the decision authorities on the transfer price and quantity to be transferred are allocated. This paper proposes a practical menu of transfer pricing mechanisms in terms of organization design in the presence of information asymmetry between a principal and two agents. The degree of decentralization determines the allocation of formal authority over the decisions on the transfer price and the production volume of the intermediate goods to be transferred. The model connects the choice of transfer pricing mechanism and organizational structure. This paper provides necessary conditions for the optimal choice of organizational structure and the allocation of the transfer pricing authority. Furthermore, this management control system may be incentive compatible and may motivate the agents in a cost-effective manner.

The results of this study complement prior studies in that the transfer pricing mechanism is more generalized and practical. The major results suggest that the transfer price is a cost-based transfer price, and that the subunits are profit centers under all forms. We characterize the optimal allocation of decision rights over the transfer pricing, meanwhile formalize its link with the organizational structure. We identify that the allocation of decision rights over transfer pricing is mainly determined by the relative importance of the private information of two agents. When necessary, the principal always allocates the authority to the agent with more valuable private information. Moreover, the degree of decentralization decreases with the importance of the private information. However, centralization is rarely the best organizational structure, due to the decline of its benefit caused by the extra constraint of one transfer price under asymmetric information in a three-tier hierarchy. Moreover, the possession of decision authority is not always beneficial to the agent.

To simplify the analysis, this paper is subject to some limitations. We do not contemplate the moral hazard problem, the effort of the agents and the incentive contract parameter are taken as exogenously give. Further, we assume that there is no limit to communication. When communication is limited, we predict the relative merits of delegation may increase because of the flexible gain in contrast to centralization. Future research could relax these limitations to observe the influence of each. We also assume that, under centralization, there is no collusion between two agents. Future research may examine these issues in light of the organization design.

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Appendix

Conditions

C1 $$E_{\theta_1\theta_2}\left\{\sqrt{\left\{a-\sum_{i=1}^{2}\left[\theta_i+\frac{e_i(\theta_i)}{\beta_i(\theta_i)}+\frac{F_i(\theta_i)}{f_i(\theta_i)}\left(1+\frac{e_i'(\theta_i)}{\beta_i(\theta_i)}\right)\right]\right\}^2+4b\sum_{i=1}^{2}\frac{\alpha_i}{\beta_i}}\right\}>E_{\theta_1\theta_2}\left[\frac{F_1(\theta_1)}{f_1(\theta_1)}\left(1+\frac{e_1'(\theta_1)}{\beta_1(\theta_1)}\right)\right],$$

C1' $$E_{\theta_1\theta_2}\left\{\sqrt{\left\{a-\sum_{i=1}^{2}\left[\theta_i+\frac{e_i(\theta_i)}{\beta_i(\theta_i)}+\frac{F_i(\theta_i)}{f_i(\theta_i)}\left(1+\frac{e_i'(\theta_i)}{\beta_i(\theta_i)}\right)\right]\right\}^2+4b\sum_{i=1}^{2}\frac{\alpha_i}{\beta_i}}\right\}<E_{\theta_1\theta_2}\left[\frac{F_1(\theta_1)}{f_1(\theta_1)}\left(1+\frac{e_1'(\theta_1)}{\beta_1(\theta_1)}\right)\right],$$

C2 $$E_{\theta_1\theta_2}\left\{\sqrt{\left\{a-\sum_{i=1}^{2}\left[\theta_i+\frac{e_i(\theta_i)}{\beta_i(\theta_i)}+\frac{F_i(\theta_i)}{f_i(\theta_i)}\left(1+\frac{e_i'(\theta_i)}{\beta_i(\theta_i)}\right)\right]\right\}^2+4b\sum_{i=1}^{2}\frac{\alpha_i}{\beta_i}}\right\}>E_{\theta_1\theta_2}\left[\frac{F_2(\theta_2)}{f_2(\theta_2)}\left(1+\frac{e_2'(\theta_2)}{\beta_2(\theta_2)}\right)\right],$$

C2' $$E_{\theta_1\theta_2}\left\{\sqrt{\left\{a-\sum_{i=1}^{2}\left[\theta_i+\frac{e_i(\theta_i)}{\beta_i(\theta_i)}+\frac{F_i(\theta_i)}{f_i(\theta_i)}\left(1+\frac{e_i'(\theta_i)}{\beta_i(\theta_i)}\right)\right]\right\}^2+4b\sum_{i=1}^{2}\frac{\alpha_i}{\beta_i}}\right\}<E_{\theta_1\theta_2}\left[\frac{F_2(\theta_2)}{f_2(\theta_2)}\left(1+\frac{e_2'(\theta_2)}{\beta_2(\theta_2)}\right)\right].$$

To facilitate the comparison of the organizational forms, we compute the difference in the quantity to be transferred under different organizational forms. Condition C1 is the difference between Q_1 and Q_c. Under condition C1, the quantity to be transferred under centralization, Q_c is greater than Q_1. When the difference of both types is smaller, then the likelihood that condition C1 will hold increases. Conversely, under condition C1', Q_c is smaller than Q_1. When the difference of both types exceeds a specific range and θ_1 is relatively large than θ_2, then the likelihood that condition C1' will hold increases. Similarly, condition C2 is the difference between Q_c and Q_2. Under condition C2, Q_c is larger than Q_2, and under condition C2', Q_c is smaller than Q_2. The conditions to compare the principal's net profit under centralization and the other organizational forms are as follows.

Conditions.

C3 $$E_{\theta_1\theta_2}\left\{\sqrt{\left\{a-\sum_{i=1}^{2}\left[\theta_i+\frac{e_i(\theta_i)}{\beta_i(\theta_i)}+\frac{F_i(\theta_i)}{f_i(\theta_i)}\left(1+\frac{e_i'(\theta_i)}{\beta_i(\theta_i)}\right)\right]\right\}^2+4b\sum_{i=1}^{2}\frac{\alpha_i}{\beta_i}}\right\},$$

$$>E_{\theta_1\theta_2}\left\{\frac{2e_1(\theta_1)}{\beta_1(\theta_1)}+\frac{F_1(\theta_1)}{f_1(\theta_1)}\cdot\left(1+\frac{e_1'(\theta_1)}{\beta_1(\theta_1)}\right)-\frac{2(1-\beta_2(\theta_2))}{(1-\beta_1(\theta_1))}\cdot\left[\frac{e_2(\theta_2)}{\beta_2(\theta_2)}+\frac{F_2(\theta_2)}{f_2(\theta_2)}\left(1+\frac{e_2'(\theta_2)}{\beta_2(\theta_2)}\right)\right]\right\}$$

C3’ $$E_{\theta_1\theta_2}\left\{\sqrt{\left\{a-\sum_{i=1}^{2}\left[\theta_i+\frac{e_i(\theta_i)}{\beta_i(\theta_i)}+\frac{F_i(\theta_i)}{f_i(\theta_i)}\left(1+\frac{e_i'(\theta_i)}{\beta_i(\theta_i)}\right)\right]\right\}^2+4b\sum_{i=1}^{2}\frac{\alpha_i}{\beta_i}}\right\},$$
$$< E_{\theta_1\theta_2}\left\{\frac{2e_1(\theta_1)}{\beta_1(\theta_1)}+\frac{F_1(\theta_1)}{f_1(\theta_1)}\cdot\left(1+\frac{e_1'(\theta_1)}{\beta_1(\theta_1)}\right)-\frac{2(1-\beta_2(\theta_2))}{(1-\beta_1(\theta_1))}\cdot\left[\frac{e_2(\theta_2)}{\beta_2(\theta_2)}+\frac{F_2(\theta_2)}{f_2(\theta_2)}\left(1+\frac{e_2'(\theta_2)}{\beta_2(\theta_2)}\right)\right]\right\}$$

C4 $$E_{\theta_1\theta_2}\left\{\sqrt{\left\{a-\sum_{i=1}^{2}\left[\theta_i+\frac{e_i(\theta_i)}{\beta_i(\theta_i)}+\frac{F_i(\theta_i)}{f_i(\theta_i)}\left(1+\frac{e_i'(\theta_i)}{\beta_i(\theta_i)}\right)\right]\right\}^2+4b\sum_{i=1}^{2}\frac{\alpha_i}{\beta_i}}\right\},$$
$$> E_{\theta_1\theta_2}\left\{\frac{2e_2(\theta_2)}{\beta_2(\theta_2)}+\frac{F_2(\theta_2)}{f_2(\theta_2)}\left(1+\frac{e_2'(\theta_2)}{\beta_2(\theta_2)}\right)-\frac{2(1-\beta_1(\theta_1))}{(1-\beta_2(\theta_2))}\cdot\left[\frac{e_1(\theta_1)}{\beta_1(\theta_1)}+\frac{F_1(\theta_1)}{f_1(\theta_1)}\cdot\left(1+\frac{e_1'(\theta_1)}{\beta_1(\theta_1)}\right)\right]\right\}$$

C4’ $$E_{\theta_1\theta_2}\left\{\sqrt{\left\{a-\sum_{i=1}^{2}\left[\theta_i+\frac{e_i(\theta_i)}{\beta_i(\theta_i)}+\frac{F_i(\theta_i)}{f_i(\theta_i)}\left(1+\frac{e_i'(\theta_i)}{\beta_i(\theta_i)}\right)\right]\right\}^2+4b\sum_{i=1}^{2}\frac{\alpha_i}{\beta_i}}\right\}.$$
$$< E_{\theta_1\theta_2}\left\{\frac{2e_2(\theta_2)}{\beta_2(\theta_2)}+\frac{F_2(\theta_2)}{f_2(\theta_2)}\left(1+\frac{e_2'(\theta_2)}{\beta_2(\theta_2)}\right)-\frac{2(1-\beta_1(\theta_1))}{(1-\beta_2(\theta_2))}\cdot\left[\frac{e_1(\theta_1)}{\beta_1(\theta_1)}+\frac{F_1(\theta_1)}{f_1(\theta_1)}\cdot\left(1+\frac{e_1'(\theta_1)}{\beta_1(\theta_1)}\right)\right]\right\}$$

As to the principal’s preference for centralization or the other four organizational forms, the principal’s profit objective function may increase or decrease with the quantity depending on the quantity that is chosen under each regime. Condition C3 is obtained by subtracting Q_1' from Q_c, where Q_1' is obtained by solving $\Pi(T_1,Q)=\Pi(T_1,Q_1)$. Under condition C3, the production volume under centralization Q_c is greater than Q_1'. Conversely, under condition C1’, Q_c is smaller than Q_1'. Similarly, condition C4 is the difference between Q_c and Q_2', where Q_2' is obtained by solving $\Pi(T_2,Q)=\Pi(T_2,Q_2)$. Under condition C4, Q_c is larger than Q_2'.

Stage 1 Stage 2

--|----------------|-------------------------|--------------------------------------|---

sourcing decision — A_i observes, θ_i, $i, j \in \{1,2\}$. — P chooses organizational form, C, D_i, or PD_i — The party with formal authority exercises his decision right.

|--|---|----------------------|

The party without formal authority accepts or rejects the offer. — If all of the offers are accepted by all parties, the mechanism is implemented; otherwise the game ends. — Outcome is realized, rewards are paid.

Figure 1: Timeline of the transfer pricing game

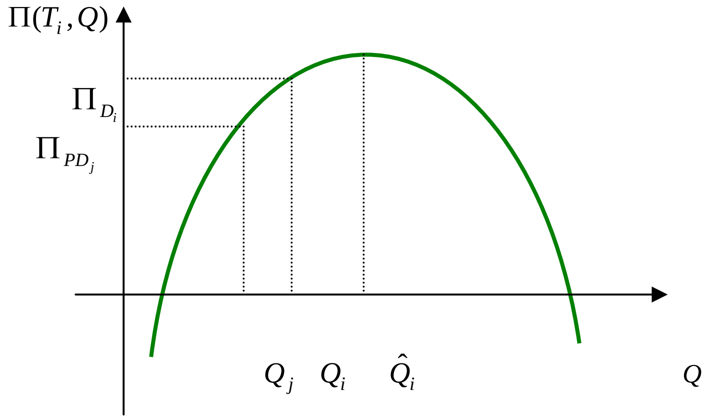

Figure 2. Comparison of D_i and PD_j when $E(\theta_i) > E(\theta_j)$

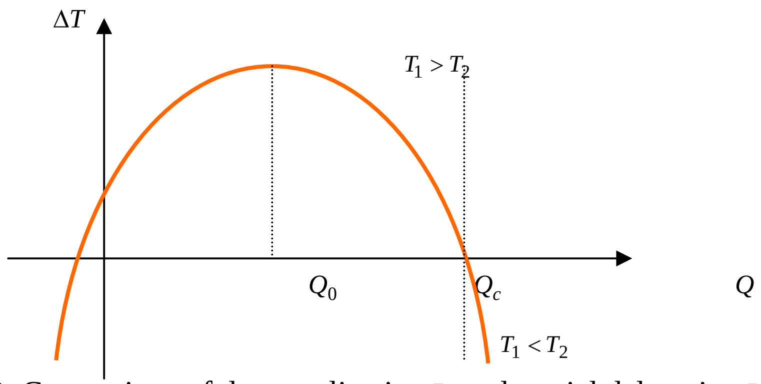

Figure 3: Comparison of decentralization D_i and partial delegation PD_i

Table 1: Comparison of the expected profit under all organizational forms

Conditions	$E(\theta_1) > E(\theta_2)$	$E(\theta_1) < E(\theta_2)$
C1', C2	$\Pi_{D_2} < \Pi_{PD_2} < \Pi_{D_1} < \Pi_{PD_1}$	
C2', C1		$\Pi_{D_1} < \Pi_{PD_1} < \Pi_{D_2} < \Pi_{PD_2}$
C1', C2'	$\Pi_{PD_2} < \Pi_{D_2} < \Pi_{D_1} < \Pi_{PD_1}$	$\Pi_{PD_1} < \Pi_{D_1} < \Pi_{D_2} < \Pi_{PD_2}$
C1, C2	$\Pi_{D_2} < \Pi_{PD_2} < \Pi_{PD_1} < \Pi_{D_1}$	$\Pi_{D_1} < \Pi_{PD_1} < \Pi_{PD_2} < \Pi_{D_2}$

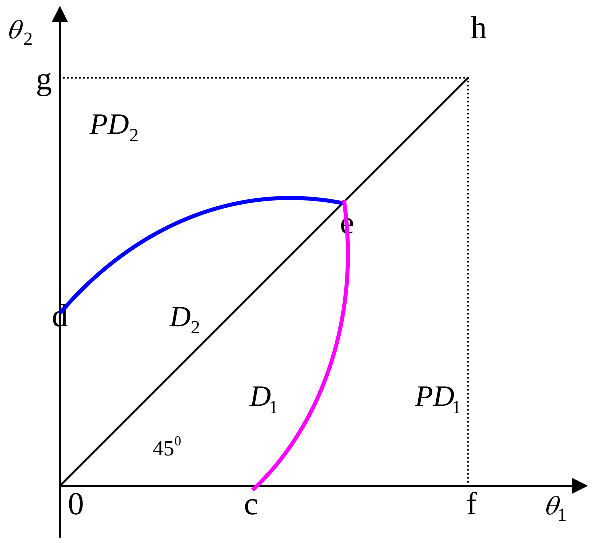

Figure 4. The principal’s optimal choice of organizational form

Table 2: Comparison of the expected profit under all organizational forms

Conditions	$E(\theta_1) > E(\theta_2)$	$E(\theta_1) < E(\theta_2)$
C1’, C2, C3’, C4’	$\Pi_{D_2} < \Pi_{PD_2} < \Pi_C < \Pi_{D_1} < \Pi_{PD_1}$	
C1, C2’, C3’, C4’		$\Pi_{D_1} < \Pi_{PD_1} < \Pi_C < \Pi_{D_2} < \Pi_{PD_2}$
C1’, C2’, C3’, C4’	$\Pi_C < \Pi_{PD_2} < \Pi_{D_2} < \Pi_{D_1} < \Pi_{PD_1}$	$\Pi_C < \Pi_{PD_1} < \Pi_{D_1} < \Pi_{D_2} < \Pi_{PD_2}$
C1, C2, C3’, C4’	$\Pi_{D_2} < \Pi_{PD_2} < \Pi_{PD_1} < \Pi_{D_1} < \Pi_C$	$\Pi_{D_1} < \Pi_{PD_1} < \Pi_{PD_2} < \Pi_{D_2} < \Pi_C$
C1, C2, C3, C4	$\Pi_C < \Pi_{D_2} < \Pi_{PD_2} < \Pi_{PD_1} < \Pi_{D_1}$	$\Pi_C < \Pi_{D_1} < \Pi_{PD_1} < \Pi_{PD_2} < \Pi_{D_2}$

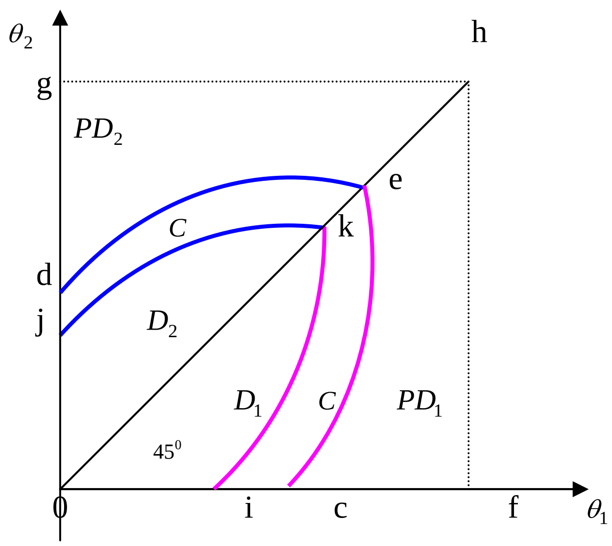

Figure 5. The principal’s optimal choice of organizational form

Appendix

Proof of Proposition 1.

Under centralization, the principal chooses q to maximize the expected income of the firm: $\underset{q}{Max}(a - bq - \sum_{i=1}^{2}\theta_i)q$. Differentiating the objective function with respect to q and rearranging terms obtain $q = \frac{1}{2}(a - \sum_{i=1}^{2}\theta_i)$. Substituting q into the linear demand function $p=a-bq$ yields the price of the final product p, which is $\frac{1}{2}(a + \sum\theta_i)$. Substituting for these two terms into the objective function yields the firm's expect profit $\frac{1}{4b}(a - \sum\theta_i)^2$. Under delegation, for any transfer price t decided by the manager of the upstream A_1, A_2 chooses q to maximize his expected utility: $\underset{q}{Max}(a - bq - t - \theta_2)q$. Differentiating the objective function with respect to q yields A_2's best response: $q(t) = \frac{1}{2b}(a - \theta_2 - t)$. Given A_2's chosen transferred quantity, $q=q(t)$, A_1 chooses the transfer price that is best for his compensation $\underset{q}{Max}(t - \theta_1)q(t)$. Differentiating with respect to t yields A_1's best response: $t = \frac{1}{2}(a + \theta_1 - \theta_2)$. Substituting t into $q(t)$ yields $q = \frac{1}{4b}(a - \sum\theta_i)$. Substituting q into linear demand function $p=a-bq$ yields the price of the final product $p = \frac{1}{4}(3a + \sum\theta_i)$. Additionally, substituting these two terms into the objective function yields the firm's expected profit $\frac{3}{16b}(a - \sum\theta_i)^2$.

Proof of Lemma1.

The agent's expected utility $U(\cdot)$ is assumed differentiable. Let

$$U_1(\theta_1;\hat{\theta}_1) \equiv \mathrm{E}_{\theta_2}[\omega_1(\theta_1;\hat{\theta}_1) - e_1(\theta_1)q(\hat{\theta}_1,\theta_2)] = \mathrm{E}_{\theta_2}\{\alpha_1(\hat{\theta}_1) + \beta_1(\hat{\theta}_1)[tq(\hat{\theta}_1,\theta_2) - \theta_1 q(\hat{\theta}_1,\theta_2)] - e_1(\theta_1)q(\hat{\theta}_1,\theta_2)\}$$

$$\frac{dU_1(\theta_1;\hat{\theta}_1)}{d\theta_1} = \frac{\partial U_1(\theta_1;\hat{\theta}_1)}{\partial\hat{\theta}_1} + \frac{\partial U_1(\theta_1;\hat{\theta}_1)}{\partial\theta_1}$$

By envelope theorem, $\frac{\partial U_1(\theta_1;\hat{\theta}_1)}{\partial\hat{\theta}_1} = 0$, therefore

$$\frac{dU_1(\theta_1;\hat{\theta}_1)}{d\theta_1} = -\mathrm{E}_{\theta_2}\left[(\beta_1(\theta_1) + e_1'(\theta_1))q(\theta_1,\theta_2)\right]$$

$$\frac{d}{d\theta_1}\mathrm{E}_{\theta_2}\left[\omega_1(\theta_1;\theta_2) - e_1(\theta_1)q(\theta_1,\theta_2)\right] = -\mathrm{E}_{\theta_2}\left[(\beta_1(\theta_1) + e_1'(\theta_1))q(\theta_1,\theta_2)\right] \quad \text{(A1)}$$

equivalently,

$$\mathrm{E}_{\theta_2}\left[\omega_1(\theta_1;\theta_2)\right] = \mathrm{E}_{\theta_2}\left[\Phi_1(\bar{\theta}_1) + e_1(\theta_1)q(\theta_1,\theta_2) + \int_{\theta_1}^{\bar{\theta}_1}\left[\beta_1(\theta_1) + e_1'(\theta_1)\right]q(\theta_1,\theta_2)d\theta_1\right] \tag{A2}$$

Integration by parts of the third term on the right-hand side of (A2) gives

$$\mathrm{E}_{\theta_1\theta_2}\left[\omega_1(\theta_1;\theta_2)\right] = \mathrm{E}_{\theta_1\theta_2}\left[\Phi_1(\bar{\theta}_1) + e_1(\theta_1)q(\theta_1,\theta_2) + \frac{F_1(\theta_1)}{f_1(\theta_1)}\left\{\left[\beta_1(t) + e_1'(t)\right]\, q(\theta_1,\theta_2) - \Phi_1(\bar{\theta}_1)\right\}\right] .$$

Similarly, the proofs of the agent A_2 's expected compensation are parallel to which has just been shown and hence omitted.

Proof of Proposition 2 to 4.

Under decentralization and partial delegation:

(i). Ignoring the global incentive constraints, from Lemma 1, the objective function can be restated as:

$$\mathrm{E}_{\theta_j}\left\{\alpha_i(\theta_i) + \beta_i(\theta_i)\left\{\left[a - bq(\theta_1,\theta_2)\right]q(\theta_1,\theta_2) - \sum_{i=1}^{2}\theta_i q(\theta_1,\theta_2) - \frac{h_j(q(\theta_1,\theta_2),\theta_j) - \alpha_j(\theta_j)}{\beta_j(\theta_j)}\right\} - e_i(\theta_i)q(\theta_1,\theta_2)\right\} \tag{A5}$$

The problem in (A5) can be solved by pointwise. Differentiating the objective function with respect to q and rearranging terms obtain yields $Q_i(\theta_1,\theta_2)$.

(ii) Recall that from Lemma 1, $E_{\theta_1\theta_2}[\omega_i(\theta_1,\theta_2)] = E_{\theta_1\theta_2}[h_i(q(\theta_1;\theta_2),\theta_i)]$. In addition,

$$E\left[\omega_2(\theta_1;\theta_2)\right] = \mathrm{E}_{\theta_1}\left\{\alpha_2(\theta_2) + \beta_2(\theta_2)\left\{\left[a - bq(\theta_1,\theta_2)\right]q(\theta_1,\theta_2) - \theta_2 q(\theta_1,\theta_2) - t(\theta_1,\theta_2)\right\}\right\}$$

$$\mathrm{E}_{\theta_1\theta_2}\left[t(\theta_1,\theta_2)\right] = \mathrm{E}_{\theta_1\theta_2}\left\{\left[a - bq(\theta_1,\theta_2)\right]q(\theta_1,\theta_2) - \theta_2 q(\theta_1,\theta_2) - \frac{h_2(q(\theta_1,\theta_2),\theta_2) - \alpha_2(\theta_2)}{\beta_2(\theta_2)}\right\} \equiv T_1(\cdot)\,,$$

where q is Q_1 under D_1, and Q_2 under PD_2. Likewise, $E\left[\omega_1(\theta_1;\theta_2)\right] = E\left\{\alpha_1(\theta_1) + \beta_1(\theta_1)\left[t(\theta_1,\theta_2) - \theta_1 q(\theta_1,\theta_2)\right]\right\}$.

Hence, $E_{\theta_1\theta_2}\left\{\alpha_1(\theta_1) + \beta_1(\theta_1)\left[t(\theta_1,\theta_2) - \theta_1 q(\theta_1,\theta_2)\right]\right\} = E_{\theta_1\theta_2}\left\{h_1(q(\theta_1,\theta_2),\theta_1)\right\}$.

$$E_{\theta_1\theta_2}\left[t(\theta_1,\theta_2)\right] = E_{\theta_1\theta_2}\left[\theta_1 q(\theta_1,\theta_2) + \frac{h_1(q(\cdot),\theta_1) - \alpha_1(\theta_1)}{\beta_1(\theta_1)}\right] \equiv T_2(q(\cdot),\theta_1,\theta_2)\,,$$

where q is Q_2 under D_2, and Q_1 under PD_1.

Under centralization:

(iii) From Lemma 1 and the constraint of one transfer price.

$$\mathrm{E}_{\theta_1\theta_2}\left[t(\theta_1,\theta_2)\right] = \mathrm{E}_{\theta_1\theta_2}\left[\frac{h_1(q(\theta_1,\theta_2),\theta_1) - \alpha_1(\theta_1)}{\beta_1(\theta_1)} + \theta_1 q(\theta_1,\theta_2)\right]$$

$$= \mathrm{E}_{\theta_1\theta_2}\left\{\left[a - bq(\theta_1,\theta_2)\right]q(\theta_1,\theta_2) - \theta_2 q(\theta_1,\theta_2) - \frac{h_2(q(\theta_1,\theta_2),\theta_2) - \alpha_2(\theta_2)}{\beta_2(\theta_2)}\right\},$$

$$\mathrm{E}_{\theta_1\theta_2}\left\{[a-bq(\theta_1,\theta_2)]q(\theta_1,\theta_2)-\sum_{i=1}^{2}\theta_i q(\theta_1,\theta_2)-\sum_{i=1}^{2}\frac{h_i(q(\theta_1,\theta_2),\theta_i)-\alpha_i(\theta_i)}{\beta_i(\theta_i)}\right\}=0\,, \tag{A6}$$

Hence only one production volume satisfies (A6), which is $Q_c(\theta_1,\theta_2)$. Moreover, there is only one transfer price, $T_1=T_2$, so

$$\mathrm{E}_{\theta_1\theta_2}[\mathrm{t}(\theta_1,\theta_2)]=\mathrm{E}_{\theta_1\theta_2}\left\{[a-bq(\theta_1,\theta_2)]q(\theta_1,\theta_2)-\theta_2 q(\theta_1,\theta_2)-\frac{h_2(q(\theta_1,\theta_2),\theta_2)-\alpha_2(\theta_2)}{\beta_2(\theta_2)}\right\}$$
$$=\mathrm{E}_{\theta_1\theta_2}\left[\frac{h_1(q(\theta_1,\theta_2),\theta_1)-\alpha_1(\theta_1)}{\beta_1(\theta_1)}+\theta_1 q(\theta_1,\theta_2)\right].$$

(iv) Under *C*, if the principal uses dual price, the transfer price is T_2 for the production department and T_1 for the marketing department. Likewise, the objective function, ignoring the global incentive constraints, can be restated as:

$$\mathrm{E}_{\theta_1\theta_2}\left\{\left[a-bq(\theta_1,\theta_2)\right]q(\theta_1,\theta_2)-\sum_{i=1}^{2}\left[\theta_i q(\theta_1,\theta_2)+h_i(q(\theta_1,\theta_2),\theta_i\right]\right\} \tag{A7}$$

where h_i is shown in Lemma 1. The problem can be solved by pointwise and gives $Q_{cd}(\theta_1,\theta_2)$.

Proof of Lemma 2. (Comparison of D_i *and* PD_j *)*

Under delegation D_i and partly delegation PD_j , $i,\, j\in\{1,2\}, i\neq j$, the expected transfer price are T_i, so the principal's expected income can be expressed as $\Pi(T_i.Q)$:

$$\Pi(T_i,q)=E_{\theta_1\theta_2}\left\{(1-\beta_i(\theta_i))\left[(a-bq)-\sum_i\theta_i\right]q-\left[\beta_j(\theta_j)-\beta_i(\theta_i)\right]\left[\frac{h_j(q)-\alpha_j(\theta_j)}{\beta_j(\theta_j)}\right]\right\},$$

where $E(q)$ is Q_i under D_i and PD_j. The principal's expected income $\Pi(T_i.Q)$ is increasing and concave in Q if $Q<\hat{Q}_i$, and decreasing and concave in Q if $Q>\hat{Q}_i$, where $\hat{Q}_i$ is obtained from differentiating $\Pi(T_i.Q)$ with respect to Q and equals

$$\hat{Q}_i=\frac{1}{2b}E_{\theta_1\theta_2}\left\{a-\sum_i\theta_i-\frac{\left[\beta_j(\theta_j)-\beta_i(\theta_i)\right]}{\left[1-\beta_i(\theta_i)\right]}\left\{\frac{e_j(\theta_j)}{\beta_j(\theta_j)}+\frac{F_j(\theta_j)}{f_j(\theta_j)}\left[1+\frac{e_j'(\theta_j)}{\beta_j(\theta_j)}\right]\right\}\right\}.$$

This means that under both D_i and PD_j, given the expected transfer price T_i, if the agent with authority chooses transferred quantity by maximizing the principal's expected income in the absence of any other constraint, then the chosen quantity should be $\hat{Q}_i$. When $E(\theta_i)>E(\theta_j)$, $Q_i>Q_j$ and $Q_i<\hat{Q}_i$, $i\in\{1,2\}$.

Because $\Pi(T_i.Q)$ is increasing and concave in Q if $Q < \hat{Q}_i$, Π_{D_i} =$\Pi(T_i, Q_i)$>$\Pi(T_i,Q_j)$= Π_{PD_j} . Hence, the principal prefers delegation D_i to partly delegation PD_j. Also, when $E(\theta_i) > E(\theta_j)$, Q_j<Q_i, $i \in \{1,2\}$. The principal's expected income $\Pi(T_j.Q)$ is increasing and concave in Q if $Q < \hat{Q}_j$, and decreasing and concave in Q if $Q > \hat{Q}_j$. By assumption A4, $Q_i < \hat{Q}_j$, $\Pi_{D_j} = \Pi(T_j, Q_j) < \Pi(T_j, Q_i) = \Pi_{PD_i}$. Hence, the principal prefers partly delegation PD_i to delegation D_j.

Proof of Lemma 3. (Comparison of D_i and PD_i)

The proofs contain two parts. The first part is to compare the principal's preference over delegation D_1 to partly delegation PD_1. The other is to compare the principal's preference over delegation D_2 to partly delegation PD_2. Given the expected transfer price T and expected quantity transferred Q, let the principal's expected income be $\Pi(T,Q)$:

$$\Pi(T,Q) = E_{\theta_1\theta_2}\left\{(1-\beta_2(\theta_2))\left[R(q)-C_2(q)\right]-(1-\beta_1(\theta_1))C_1(q)-(\beta_1(\theta_1)-\beta_2(\theta_2))\cdot t-\sum_i \alpha_i(\theta_i)\right\},$$

where $R(q)=(a-bq)q, C_i(q) = \theta_i q,\ i \in \{1,2\}$. Under both delegation D_1 and partly delegation PD_1, the expected quantity transferred are all Q_1, while the expected transfer price is T_1 and T_2, respectively. Under these two organizations, the difference of the principal's expected income is $\Pi(T_1,Q_1)$-$\Pi(T_2,Q_1)$ and equals $E_{\theta_1\theta_2}\left[(\beta_2(\theta_2)-\beta_1(\theta_1))(T_1(\cdot)-T_2(\cdot))\right]$. Let T_1-T_2 be ΔT. If Q<Q_0, then ΔT is increasing and concave in Q; if $Q > Q_0$, then ΔT is decreasing and concave in Q, where Q_0 is obtained from differentiating ΔT with respect to Q, $Q_0(\cdot) = \dfrac{1}{2b}E_{\theta_1\theta_2}\{a-\sum_{i=1}^{2}\{\theta_i + \dfrac{e_i(\theta_i)}{\beta_i(\theta_i)} + \dfrac{F_i(\theta_i)}{f_i(\theta_i)}[1+\dfrac{e_i'(\theta_i)}{\beta_i(\theta_i)}]\}$. Furthermore, ΔT is quadratic form of the transferred quantity. LetΔT be zero and obtain the roots zero and Q_c. The figure can be depicted as Figure 3.

Two cases are explained as follows. (i) Taking into account the net effect of the incentive pay to two agents on the principal's expected income, $E_\theta(\beta_2(\cdot)-\beta_1(\cdot))\Delta T(\cdot)$, which shows that the greater the difference of the expected transfer price ΔT, the more profitable the principal's income. Under condition C1, Q_0<Q_1<Q_c. As shown in figure 3, ΔT is positive. When $E(\theta_1) > E(\theta_2)$, from assumption

A4, we know that $\beta_2(\theta_2) > \beta_1(\theta_1)$ and so $\Pi(T_1, Q_1) = \Pi_{D_1}$ exceeds $\Pi(T_2, Q_1) = \Pi_{PD_1}$. Hence, the principal prefers delegation D_1 to partly delegation PD_1. Contrarily, when $E(\theta_1) < E(\theta_2)$, $\beta_2(\theta_2) < \beta_1(\theta_1)$, the above results are reversed, i.e., $\Pi(T_1, Q_1) = \Pi_{D_1}$ is lower than $\Pi(T_2, Q_1) = \Pi_{PD_1}$, the principal prefers partly delegation PD_1 to delegation D_1. In contrast, under condition C1', $Q_1 > Q_c$, and ΔT is negative. When $E(\theta_1) > E(\theta_2)$, $\beta_2(\theta_2) > \beta_1(\theta_1)$ and then $\Pi_{D_1} < \Pi_{PD_1}$, the principal prefers partly delegation PD_1 to delegation D_1. Conversely, when $E(\theta_1) < E(\theta_2)$, $\beta_2(\theta_2) < \beta_1(\theta_1)$, $\Pi_{D_1} > \Pi_{PD_1}$, the principal prefers delegation D_1 to partly delegation PD_1. (ii) To compare decentralization D_2 and partly delegation PD_2, the difference of income under these structures is:

$$\Pi_{D_2} - \Pi_{PD_2} = \Pi(T_2, Q_2) - \Pi(T_1, Q_2) = E_{\theta_1\theta_2}\left[(\beta_1(\theta_1) - \beta_2(\theta_2))(T_1(Q_2) - T_2(Q_2))\right] .$$

The comparison is as which just being shown and hence be omitted.

Proof of Corollary 2.

Conditions C1, C1', C2, or C2', and Lemma 3 and Lemma 2 complete the proof.

Proof of Lemma 4. (Comparison of C to D_1, and C to D_2)

Recall from Lemma 2, the principal's expected income $\Pi(T_i.Q)$ is increasing and concave in Q if $Q < \hat{Q}_i$, and decreasing and concave in Q if $Q > \hat{Q}_i$, where $\hat{Q}_i$ is obtained from differentiating $\Pi(T_i.Q)$ with respect to Q, where $\hat{Q}_i = \frac{1}{2b} E_{\theta_1\theta_2}\left\{a - \sum_i \theta_i - \frac{\left[\beta_j(\theta_j) - \beta_i(\theta_i)\right]}{\left[1 - \beta_i(\theta_i)\right]}\left\{\frac{e_j(\theta_j)}{\beta_j(\theta_j)} + \frac{F_j(\theta_j)}{f_j(\theta_j)}\left[1 + \frac{e_j'(\theta_j)}{\beta_j(\theta_j)}\right]\right\}\right\}$.

Let $\Pi(T_i, Q_i) \equiv \Pi_i$, solving $\Pi(T_i, Q) \equiv \Pi_i$ obtains two roots Q_i and Q_i', where

$$Q_i'(\theta_1, \theta_2) = \frac{1}{2b} E_{\theta_1\theta_2}\left\{a - \sum_{i=1}^{2}\theta_i + \frac{e_i(\theta_i)}{\beta_i(\theta_i)} + \frac{1 - 2\beta_j(\theta_j) + \beta_i(\theta_i)}{(1 - \beta_i(\theta_i))} \cdot \left[\frac{e_j(\theta_j)}{\beta_j(\theta_j)} + \frac{F_j(\theta_j)}{f_j(\theta_j)} \cdot \left(1 + \frac{e_j'(\theta_j)}{\beta_j(\theta_j)}\right)\right]\right\}$$

Two cases are examined as follows.

1. $E(\theta_1) > E(\theta_2)$, $Q_2 < Q_1 < \hat{Q}_1 < Q_1'$, $\Pi(T_1, Q)$ is increasing if $Q < \hat{Q}_1$, and decreasing if $Q > \hat{Q}_1$. (i) If C3 holds, $Q_c > Q_1'$, $\Pi(T_1, Q_c) < \Pi(T_1, Q_1)$, $\Pi_C < \Pi_{D_1}$. (ii). If C3' holds, $Q_c < Q_1'$, under C1, $Q_c \in (Q_1, Q_1')$, $\Pi_C > \Pi_{D_1}$; under C1', $Q_c < Q_1$, $\Pi_C < \Pi_{D_1}$. Likewise, when $E(\theta_1) > E(\theta_2)$,

$Q_2 < Q_1 < \hat{Q}_2 < Q_2'$. (i). If C4 holds, $Q_c > Q_2'$, $\Pi(T_2, Q_c) < \Pi(T_2, Q_2)$, $\prod_C < \prod_{D_2}$. (ii). If C4' holds, $Q_c < Q_2'$; for $Q_c \in (Q_2, Q_2')$, $\prod_C > \prod_{D_2}$; for C2' holds, $Q_c < Q_2$, $\prod_C < \prod_{D_2}$.

2. $E(\theta_1) < E(\theta_2)$, $Q_1 < Q_2 < \hat{Q}_1 < Q_1'$, there are two cases to examine: (i). If C3 holds, $Q_c > Q_1'$, $\Pi(T_1, Q_c) < \Pi(T_1, Q_1)$, $\prod_C < \prod_{D_1}$. (ii). If C3' holds, $Q_c < Q_1'$, under C1, $Q_c \in (Q_1, Q_1')$, $\prod_C > \prod_{D_1}$; under C1', $Q_c < Q_1$, $\prod_C < \prod_{D_1}$. Likewise, if $E(\theta_1) < E(\theta_2)$, $Q_1 < Q_2 < \hat{Q}_2 < Q_2'$. (i). If C4 holds, $Q_c > Q_2'$, $\Pi(T_2, Q_c) < \Pi(T_2, Q_2)$ $\prod_C < \prod_{D_2}$.(ii). If C4' hold and C2 hold, $Q_c < Q_2'$, $Q_c \in (Q_2, Q_2')$, $\prod_C > \prod_{D_2}$; for $Q_c < Q_2$ (C2'), $\prod_C < \prod_{D_2}$.

Therefore, the principal prefers D_1 to C, if C3 holds, or if C3' and C1' hold ($Q_c < Q_1$). If C3' and C1 hold ($Q_c \in (Q_1, Q_1')$), the principal prefers C to D_1. Moreover, the principal prefers D_2 to C, if C4 holds, or if C4' and C2' holds ($Q_c < Q_2$). If C4' holds, under C2, $Q_c \in (Q_2, Q_2')$, the principal prefers C to D_2.

Proof of Lemma 5. (Comparison of C to PD_1, and C to PD_2)

Let $\Pi(T_i, Q_j) \equiv \Pi_{i,j}$, $i, j \in \{1,2\}$, solving $\Pi(T_i, Q) = \Pi_{i,j}$ obtains two roots Q_j and $Q_{j,i}'$, where

$$Q_{j,i}' = \frac{1}{2b} E_{\theta_1\theta_2}\left[a - \sum_{i=1}^{2}\theta_i + \frac{e_i(\theta_i)}{\beta_i(\theta_i)} + \frac{1+\beta_i(\theta_i) - 2\beta_j(\theta_j)}{(1-\beta_i(\theta_i))} \cdot \frac{e_j(\theta_j)}{\beta_j(\theta_j)} + \frac{F_i(\theta_i)}{f_i(\theta_i)} \cdot \left(1 + \frac{e_i'(\theta_i)}{\beta_i(\theta_i)}\right) - \frac{2(\beta_j(\theta_j) - \beta_i(\theta_i))}{1-\beta_i(\theta_i)} \cdot \frac{F_j(\theta_j)}{f_j(\theta_j)} \cdot \left(1 + \frac{e_j'(\theta_j)}{\beta_j(\theta_j)}\right)\right].$$

The proofs are parallel to which has just be shown in Lemma 4 and hence omitted.

Proof of Proposition 4 to Proposition 6.

Lemma 2, Lemma 3, Lemma 4, and Lemma 5 complete the proofs.