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Specific Investment Under Negotiated Transfer Pricing: An Efficiency Result

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ABSTRACT: In our model of negotiated transfer pricing, divisional managers can make specific investments that enhance the value of intrafirm trade. However, these investments are irreversible and must be made before divisional managers have enough information to determine the desired intrafirm transfer. We find that a system of negotiated transfer pricing will lead to efficient outcomes provided the divisions can sign fixed-price contracts prior to making their investment decisions. While these contracts are likely to be renegotiated after the relevant information becomes known, they nonetheless provide the divisions with effective protection for their specific investments.

Key Words: *Decentralization, Transfer pricing, Negotiation, Investment.*

I. INTRODUCTION

SURVEYS indicate that negotiated transfer pricing is a common way of accounting for the exchange of goods and services between the divisions (profit centers) of a firm.[1] In its purest form, negotiated transfer pricing is a *laissez-faire* system in which headquarters

[1] See, for example, Price Waterhouse (1984) and Eccles (1985).

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(H.Q.) gives the divisions complete control over divisional trade and the compensating accounting charges. As a consequence, all transactions must be mutually agreeable to the divisions involved. Such a system stands in contrast to administered transfer pricing which limits the autonomy of divisions.[2]

It is commonly agreed that a major function of transfer pricing is to achieve coordination among the divisions of a firm. In the first place, divisional managers are supposed to focus on the profits of their own divisions. In order to induce effort and to mitigate problems of moral hazard, managerial compensation is generally tied to divisional profit. At the same time, the transfer pricing system should facilitate those intrafirm transactions that are in the entire firm's interest.

One would expect a tension between divisional and corporate profits when one division can undertake specific investments that are of little or no value in the division's external lines of business. For instance, the supplying division may incur an upfront fixed cost which lowers its variable cost of producing an intermediate product used by the buying division. Without a viable external market, management of the supplying division may be reluctant to incur such an expense.[3] To counteract such tendencies, central management could seek to impose an administered transfer pricing policy. Our main finding, though, is that a decentralized system of divisional profit measurement combined with negotiated transfer pricing can create desirable managerial incentives at the divisional level and, at the same time, solve the intrafirm resource allocation problem.

The scenario considered in this paper assumes that divisional managers have symmetric information about the profitability of intracompany trade. However, neither division can verify the levels of specific investment or the relevant revenue and cost information to a third party such as H.Q. At the outset, the division managers can agree to a simple fixed-price contract, which specifies the quantity of the intermediate product to be transferred and the corresponding transfer payment. Subsequently, the divisional managers independently undertake their specific investments. When the relevant revenue and cost information becomes available to both parties (but not to H.Q.), the prior agreement can be renegotiated to take advantage of the new information.

Williamson (1985, chapter 1) and others have identified the "hold-up" problem for bilateral trading problems with specific investment. To illustrate the problem, suppose the parties do not sign a prior contract. Assuming equal bargaining strength, each party expects to receive half of the ultimate gains from trade. But these gains will not account for the prior investments since those investments are sunk at the later negotiation date. As a consequence, each party will tend to underinvest: it earns half of the expected gains from trade but bears the full cost of its own investment. Holmstrom and Tirole (1991) formalize this argument to conclude that negotiated transfer pricing suffers from underinvestment.

When the divisions sign a simple fixed-price contract prior to investing, this agreement determines the status quo point in the final negotiation. The incentive to invest then has two components. For instance, if the supplying division spends a dollar on specific investment, it expects to receive half of the corresponding increase in joint profits (assuming equal bargaining power). In addition, the dollar of investment reduces the cost of producing the status-quo quantity, and thereby increases the resulting divisional payoff. For a suitable choice of the status-quo quantity, the latter effect provides the "other half" of the desired investment incentive.

Earlier work on the hold-up problem has shown that the optimal level of specific investment can be obtained in equilibrium if the parties can commit themselves to play a particular game

[2] See Kaplan and Atkinson (1989) and Eccles and White (1988).

[3] Eccles and White (1988, 542–543) illustrate this tendency to underinvest in relationship specific assets in the context of "Bacon and Bentham."

(mechanism) at the renegotiation date. The game is to be designed so that its equilibrium outcome varies with the underlying state in a way that provides each party with the appropriate investment incentives. The papers by Rogerson (1992), Hermalin and Katz (1993), Aghion et al. (1994) fall into that category.[4] In Chung (1991) and Aghion et al. (1994) the parties also sign a fixed-price contract at the outset, but in addition, they contractually agree to a particular renegotiation mechanism.[5]

Most of the recent work on transfer pricing has been concerned with administered transfer pricing; see, for example, Harris et al. (1982), Jordan (1989), Christensen and Demski (1990), Amershi and Cheng (1990), and Ronen and Balachandran (1988). In these models, H.Q. specifies a transfer-pricing formula based on divisional reports and observed variables such as production cost. Negotiated and cost-based transfer pricing are studied in Mookherjee and Reichelstein (1992) and Vaysman (1994a, 1994b). These models allow for private information about divisional revenues and costs; however, they do not consider the possibility that divisions may incur upfront fixed costs which enhance the value of intracompany transfers.

The paper is organized as follows. Section II describes the model. Initially, we shall take it as given that each divisional manager maximizes his/her division's expected profit. Proposition 2 in section III shows that when a certain separability assumption is satisfied, negotiated transfer pricing will induce efficient investments and quantity transfers. In section IV, the previous setting is embedded in a larger model, where divisional managers are subject to moral hazard. Proposition 3 shows that H.Q. can solve the combined managerial incentive and intrafirm transfer problem by offering each manager a compensation function that is linear in divisional income. The paper concludes in section V.

II. THE MODEL

Consider a multidivisional firm with headquarters (H.Q.) and two divisions. The two divisions are assumed to operate in separate markets except for an intermediate product which Division 1 (the "upstream" division) can supply to Division 2, the "downstream" division. Suppose there is no external market for the intermediate product because it is highly specialized. For this good the two divisions are thus in a bilateral monopoly situation.

If q units of the intermediate product are transferred, Division 1 incurs an incremental cost $C(q, \theta, I_1)$, where θ denotes a state variable which is unknown at the outset and I_1 represents the dollar amount of specific investment undertaken by Division 1. For example, the selling division may acquire fixed assets which reduce the variable cost of producing q. Similarly, the buying division receives an incremental revenue $R(q, \theta, I_2)$, if its specific investment was I_2, q units are transferred, and the state of the world is θ.[6] This revenue is stated net of any finishing costs incurred by Division 2 to sell its output externally.

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[4] A survey of recent papers addressing the hold-up problem is provided in Edlin and Reichelstein (1994).

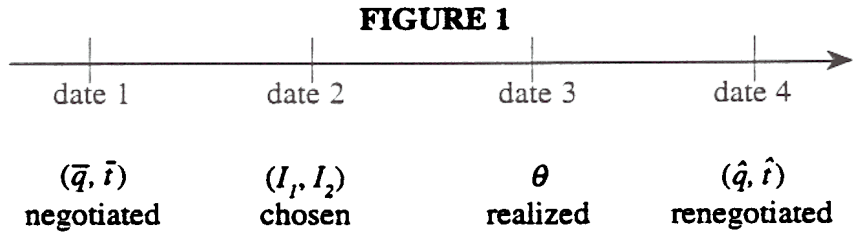
[5] In Chung's (1991) model, the original agreement specifies that one party can make a take-it-or-leave-it offer to the other party at the final negotiation stage. Chung shows that when one party captures the entire ex post surplus, the original fixed-price contract can be structured so that both sides will invest efficiently. In order for such an arrangement to be credible, however, the party receiving the take-it-or-leave-it offer must believe that if it left the offer, there would be no further negotiation, and, in particular, no subsequent surplus sharing. In effect, H.Q. would have to ensure that once the offer is rejected, the good in question not be traded between the divisions. Such stipulations appear impractical and would run contrary to the notion of profit center autonomy.

[6] In our model, the variables q, I_1, and I_2 are all real-valued, while the state variable θ can be of arbitrary dimension. A special case of interest is when $\theta \equiv (\theta_1, \theta_2)$, θ_1 affects the revenue function, θ_2 affects the cost function and the two components of θ are stochastically independent.

Under a system of negotiated transfer pricing, the two divisions have to agree on a pair (q,t), where t is the transfer payment which is charged against the buyer's divisional income and credited to the seller's income. We note that negotiated transfer pricing makes it unnecessary to compute a unit price (though for inventory valuation purposes one may need to divide t by q). In contrast, a cost-based transfer pricing rule may allow the buying division to decide on the quantity transfer at a given unit price which is based on the supplier's cost.

The sequence of events is as follows (see figure 1). At date 1, the division managers negotiate a fixed-price contract $(\bar{q}, \bar{t})$. Subsequently, the divisions undertake their specific investments I_1 and I_2. At date 3, both divisions observe the state variable θ. In addition, each division manager is assumed to learn the other party's cost or revenue function, respectively. This informational situation may result because each division observes the other's investment or simply because financial information "leaks" across divisions. As a consequence, at date 4 the two parties have complete information about the incremental costs and revenues that result from transferring q units of the intermediate product. The divisions may then negotiate a new transaction $(\hat{q}, \hat{t})$ which replaces the original agreement $(\bar{q}, \bar{t})$ of date 1.

FIGURE 1



While the two divisions have symmetric information at all dates, H.Q. is assumed to observe neither the investments nor the actual state θ. This information asymmetry makes it necessary for H.Q. to design a mechanism that achieves coordination between the divisions. We assume that all parties share the same beliefs about θ; these beliefs are represented by a probability distribution $F(\cdot)$ defined on the set of possible states.[7]

The specific investments decrease cost and increase revenue, respectively. We assume that both functions are twice differentiable in q and $I_i, i=1, 2$, and that the contribution margin $R(\cdot, \theta, I_2) - C(\cdot, \theta, I_1)$ is strictly concave in q for all θ, I_1 and I_2. The transfer quantity q is restricted to the interval $[0, q_{max}]$. Given particular levels of investment I_1 and I_2, and state realization θ, the efficient transfer quantity will be denoted by $q^*(\theta, I)$ where $I \equiv (I_1, I_2)$. Thus $q^*(\cdot)$ is the unique maximizer of:

$$M(q, \theta, I) \equiv R(q, \theta, I_2) - C(q, \theta, I_1).$$

the contribution to the firm's overall profit. Let $M(\theta, I) \equiv M(q^*(\theta, I), \theta, I)$. The efficient levels of investment are the ones that maximize the firm's expected profit,

$$\Gamma(I) \equiv E_\theta\,[M(\theta, I)] - I_1 - I_2. \tag{1}$$

[7] Our model may be viewed as an extreme case of the setting in Demski and Sappington (1984), (1989), where agents have private but correlated information. In our model the correlation is perfect. For models without specific investment, it is well known that with risk neutral agents the principal can achieve first-best allocations by designing a suitable revelation mechanism. We find that a transfer pricing mechanism that entails no reporting to H.Q. can also achieve first-best investments and allocations.

Here, the symbol $E_\theta[\cdot]$ represents the expected value of a function with respect to the probability distribution $F(\cdot)$.[8] Each division's investment is restricted to the interval $[0, I_{max}]$. We shall use the following assumptions:

(A1) $\frac{\partial^2}{\partial q \partial I_2} R(q, \theta, I_2) > 0$ and $\frac{\partial^2}{\partial q \partial I_1} C(q, \theta, I_1) < 0$ for all q, θ, I_1 and I_2.

(A2) The profit function $\Gamma(\cdot)$ has a unique maximum at $I^* = (I_1^*, I_2^*)$, with I_i^* in the interior of $[0, I_{max}]$.

Assumption (A1) says that the specific investments increase marginal revenue associated with any given q and decrease the marginal cost. For instance, we may think of I_1 as an expenditure for equipment that reduces the direct labor cost of each unit of the intermediate product. A direct consequence of (A1) is that specific investments increase the optimal transfer quantity q^* (provided $q_{max} > q^* > 0$). Assumption (A2), in conjunction with the Envelope Theorem, implies that the optimal investments satisfy the following conditions:

$$-E_\theta\left\{\frac{\partial}{\partial I_1} C(q^*(\theta, I_1^*), \theta, I_1^*)\right\} = \tag{2}$$

and

$$E_\theta\left\{\frac{\partial}{\partial I_2} \qquad)\right\} = 1. \tag{3}$$

To derive some of our results it will be convenient to impose the following technical condition:

(A2') Assumption (A2) holds and $q^*(\theta, I_1, I_2)$ is interior in $[0, q_{max}]$ for all θ, I_1 and I_2.

Central management is assumed to observe only the divisional income figures, denoted by Π_1 and Π_2. The incremental contributions to divisional income, $\Delta\Pi_i$, resulting from investments and intracompany transfers are given by: $\Delta\Pi_2 = R(q, \theta, I_2) - t - I_2$ and $\Delta\Pi_1 = t - C(q, \theta, I_1) - I_1$. Thus specific investment becomes an expense for each division, but imposes no personal costs on the manager. To the extent that divisional managers seek to increase their own division's income, though, they may have a natural tendency to underinvest.

III. INVESTMENT UNDER NEGOTIATED TRANSFER PRICING

To assess the effectiveness of negotiated transfer pricing, one needs to specify how the division managers bargain with each other. We suppose that the parties agree on an efficient transfer (from the perspective of the bargainers) and a corresponding transfer payment that splits the available surplus. At date 1, each division manager expects the current agreement to be renegotiated at date 4, when all cost and revenue uncertainty has been resolved.

We postulate that either division could insist on fulfilling the date 1 agreement, and therefore this agreement defines the status quo (or disagreement point) in the negotiation at date 4. For

[8] Formally, $E_\theta[\cdot] \equiv \int [\cdot] dF(\theta)$.

instance, the parties may instruct the bookkeeping office to record $(\bar{q}, \bar{t})$ at date 4 unless both sides agree to a different transaction $(\hat{q}, \hat{t})$. This instruction produces a rule similar to the *specific performance* remedy in contract law.[9] Such a rule allows neither party to breach a contract unilaterally; it stands in contrast to a damage rule which would allow either party to breach the date 1 contract and pay the other party damages.

Expectation damages is a more common remedy than specific performance in commercial disputes. Edlin and Reichelstein (1994) show that the expectation damages remedy is not well suited to solve bilateral investment problems. Our results therefore suggest that a vertically integrated firm, which adopts the specific performance rule, may have an advantage over a system of inter-firm transactions, which is accompanied by an expectation damages remedy. We are not aware of any large sample surveys documenting what breach remedies are prevalent in multidivisional firms. Based on their field studies, though, Meurer (1993) and Shelanski (1993) provide some empirical support for the use of the specific performance rule.

In the following analysis, we refer to the γ-surplus sharing rule as that giving Division 1 the γ-share ($0 \leq \gamma \leq 1$) of the available surplus and Division 2 the remaining $(1-\gamma)$-share. If the divisions agree to the prior contract $(\bar{q}, \bar{t})$ at date 1, and subsequently invest I_1 and I_2, respectively, the renegotiation surplus available in state θ is given by:

$$M(\theta, I) - M(\bar{q}, \theta, I). \tag{4}$$

Under γ-surplus sharing, the parties will agree to the contract $(\hat{q}, \hat{t})$ at date 4, where $\hat{q}$ is the efficient intracompany transfer, i.e., $\hat{q} = q^*(\theta, I)$ and the transfer payment satisfies:

$$R(q^*(\theta, I), \theta, I_2) - \hat{t} = R(\bar{q}, \theta, I_2) - \bar{t} + (1-\gamma)\cdot[M(\theta, I) - M(\bar{q}, \theta, I)], \tag{5}$$

$$\hat{t} - C(q^*(\theta, I), \theta, I_1) = \bar{t} - C(\bar{q}, \theta, I_1) + \gamma\cdot[M(\theta, I) - M(\bar{q}, \theta, I)]. \tag{6}$$

At date 1, the status quo point is $(q,t) = (0,0)$ since either division may refuse trade. The date 1 transfer payment $\bar{t}$ can also be derived from the rules of surplus sharing. However, since this transfer payment does not affect the divisions' subsequent incentives, we will not calculate it explicitly. We note that when $\gamma = \frac{1}{2}$, the bargaining solution in (5) corresponds to the Nash bargaining solution. In the derivation of our results we first take the parameter γ as fixed and assume that $0 < \gamma < 1$. Variations in γ and the extreme cases of $\gamma = 0$ or $\gamma = 1$ will be discussed below.

Following the agreement $(\bar{q}, \bar{t})$ at date 1, Division 1 will choose its investment so as to maximize the expected contribution to its divisional income. Formally, Division 1 maximizes:

$$\Gamma_1(I_1, I_2, \bar{q}) \equiv E_\theta\{\bar{t} - C(\bar{q}, \theta, I_1) + \gamma\cdot[M(\theta, I) - M(\bar{q}, \theta, I)]\} - I_1 \tag{7}$$

with respect to I_1, given its conjecture about the investment I_2 made by the other division. We denote by $\hat{I}_1(\bar{q}, I_2)$ the maximizers of (7). (It is possible that $\hat{I}_1(\bar{q}, I_2)$ is a set since there may be multiple maximizers.) Analogous to (7), we define $\Gamma_2(I_1, I_2, \bar{q})$ based on the right-hand side of equation (5). The optimal specific investments for Division 2 are denoted by $\hat{I}_2(\bar{q}, I_1)$.

[9] Unlike our specific performance analysis of interfirm trade (see Edlin and Reichelstein (1994)), in the current model the bookkeeping office serves the purpose of ensuring that the date 1 agreement is a credible threat. Alternatively, the parties could sign an agreement amongst themselves knowing that either side could subsequently ask H.Q. to uphold the agreement. The date 1 contract can always be structured so that one division would prefer to fulfill this contract rather than not trade at all.

Our first result examines how each division's optimal investment responds to changes in the transfer quantity $\bar{q}$ agreed to at date 1 and to changes in the other division's investment. We say that $\hat{I}_1(\bar{q}, I_2)$ is strictly increasing in $\bar{q}$ and I_2, if for any $\bar{q}, I_2, \Delta\bar{q} \geq 0$ and $\Delta I_2 \geq 0$, the following is true. If $I_1 \in \hat{I}_1(\bar{q}, I_2)$, with $I_{max} > I_1 > 0$, and $\tilde{I}_1 \in \hat{I}_1(\bar{q} + \Delta\bar{q}, I_2 + \Delta I_2)$, then $\tilde{I}_1 > I_1$ (unless, of course, $\Delta\bar{q} = 0 = \Delta\tilde{I}_2$).

Proposition 1: Given assumptions (A1) and (A2'), $\hat{I}_1(\bar{q}, I_2)$ is strictly increasing in $\bar{q}$ and I_2. Similarly, $\hat{I}_2(\bar{q}, I_1)$ is strictly increasing in $\bar{q}$ and I_1.

The proof of Proposition 1 is given in the appendix. To provide the intuition behind the result, we note that equation (7) implies that for given $\bar{q}$ and I_2, the first order condition for Division 1's optimal investment choice is:

$$E_\theta\left\{-(1-\gamma)\cdot\frac{\partial}{\partial I_1}C(\bar{q},\theta,I_1)-\gamma\cdot\frac{\partial}{\partial I}C(q^*(\theta,I),\theta,I_1)\right\}= \tag{8}$$

Comparison of equations (2) and (8) shows that if $\bar{q} = 0$ (and $\frac{\partial}{\partial I_1}C(0,\theta,I_1) \equiv 0$), Division 1 will tend to underinvest, when $I_2 = I_2^*$. This is the hold-up situation discussed by Williamson (1985) and others. Because Division 1 receives only a share of the firm's marginal return to investment, it is unwilling to invest the efficient amount. When $\bar{q}$ is positive, however, Division 1 receives an indirect benefit from its specific investment as well. Higher investment allows Division 1 to produce the quantity $\bar{q}$ at lower cost. Though this quantity will generally not be delivered in equilibrium, the potential cost reduction raises Division 1's status quo payoff at date 4, and, as shown in equation (8), Division 1 will receive an additional return for its investment.

Figure 2 illustrates Proposition 1 for two alternative values of $\bar{q}$. For simplicity, we assume in this illustration that each division has a unique best response, i.e., the sets $\hat{I}_i(\cdot)$ are single valued. The two intersection points, A and B, in figure 2 identify investment levels that form a Nash equilibrium at date 2, given the respective prior agreement $\bar{q}_L$ or $\bar{q}_H$. Figure 2 suggests that if for some reason Division 2 were constrained to choose $I_2 = I_2^*$ (possibly because the investment I_2 is observable), then there would exist some transfer quantity $\bar{q}$, with $\bar{q}_L < \bar{q} < \bar{q}_H$, which would provide Division 1 with the desired incentives. In particular, Division 1's reaction curve $\hat{I}_1(\bar{q}, \cdot)$ would pass through the point (I_1^*, I_2^*).[10]

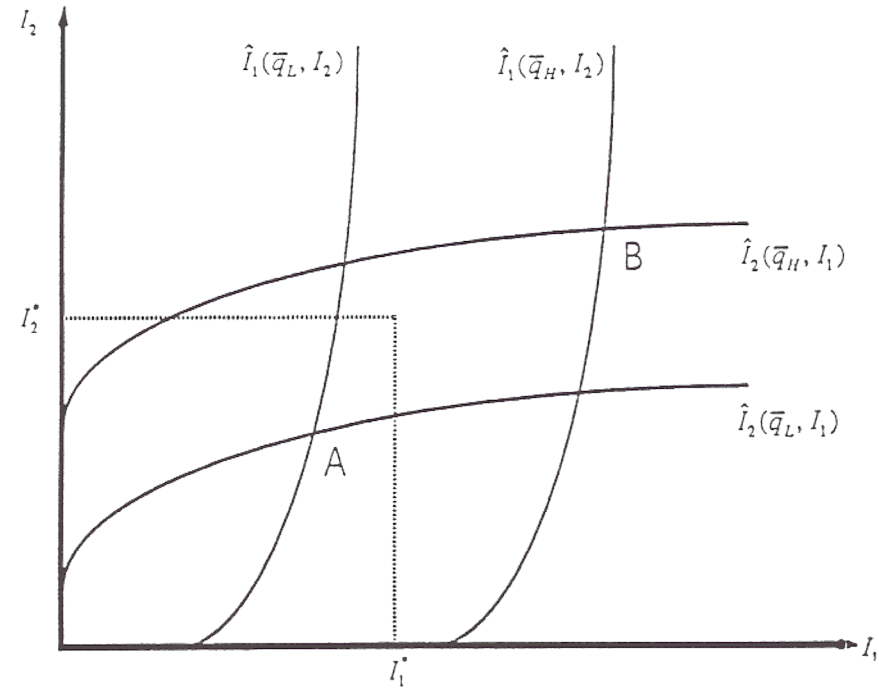
For our two-sided investment problem, it appears generally impossible that a single quantity $\bar{q}$ could induce both divisions to undertake the efficient investments I_1^* and I_2^*, respectively. An important special case of our model, however, occurs when the revenue and cost functions satisfy the following separability assumption:

(A3)
$$R(q, \theta, I_2) = R_1(I_2)\cdot q + R_2(q, \theta) + R_3(\theta, I_2)$$
$$C(q, \theta, I_1) = C_1(I_1)\cdot q + C_2(q, \theta) + C_3(\theta, I_1).$$

The economic interpretation of this separability assumption is straightforward: a dollar of specific investment by Division 1 reduces the unit variable cost of the intermediate product by $C_1'(I_1)$, independent of the actual state θ. This feature is consistent with the interpretation given

[10] Proposition 1 in Edlin and Reichelstein (1994) shows under certain regularity conditions a quantity $\bar{q}$ exists, which solves a one-sided investment problem.

FIGURE 2



before, where specific investment takes the form of production equipment that lowers direct labor costs for each unit of output. As before, we shall invoke assumption (A1), so that $R_I'(I_2) > 0$ and $C_I'(I_1) < 0$.

Proposition 2: Given (A1) - (A3), if the parties agree to the prior quantity:

$$\bar{q} = E_\theta[q^*(\theta, I_1^*, I_2^*)] \tag{9}$$

at date 1, then the efficient investment levels I_1^* and I_2^* form a Nash equilibrium at date 2.

Proof: We demonstrate only that I_1^* is an optimal choice for the supplying division given the conjecture that $I_2 = I_2^*$. One can make a symmetric argument for the buying division. Suppose Division 1 conjectures that Division 2 will invest the efficient amount I_2^*. As argued above, Division 1's best response satisfies the first-order condition given by (8). If $\bar{q}$ is chosen according to (9) and the cost function $C(q, \theta, I_1)$ satisfies the separability assumption A3, then:

$$E_\theta\left\{\frac{\partial}{\partial I_1} C(\bar{q}, \theta, I_1)\right\} = \bar{q} \cdot C_I'(I_1) + E_\theta\left\{\frac{\partial}{\partial I_1} C_3(\theta, I_1)\right\}$$
$$= E_\theta\left\{\frac{\partial}{\partial I_1} C(q^*(\theta, I^*), \theta, I_1)\right\}$$

for all I_1. Recalling equation (2), we conclude that $\frac{\partial}{\partial I_1}\Gamma_1(I_1, I_2^*, \bar{q}) = 0$ at $I_1 = I_1^*$.

It remains to show that I_1^* is indeed a global maximizer of $\Gamma_1(\cdot, I_2^*, \bar{q})$. We note that when $\bar{q} = E_\theta[q^*(\theta, I_1^*, I_2^*)]$,

$$\frac{\partial}{\partial I}\Gamma_1(I_1, I_2^*, \bar{q}) \geq \frac{\partial}{\partial I}\Gamma(I_1, I_2^*)$$

for $I_1 < I_1^*$, while the opposite inequality holds for $I_1 > I_1^*$. Both inequalities follow immediately from the fact that $E_\theta\,[q^*(\theta, I_1, I_2^*)]$ is (weakly) increasing in I_1. Therefore,

$$\begin{aligned}\Gamma_1(I_1^*, I_2^*, \bar{q}) - \Gamma_1(I_1, I_2^*, \bar{q}) &= \int_{I_1}^{I_1^*} \frac{\partial}{\partial I_1}\Gamma_1(t, I_2^*, \bar{q})dt \geq \int_{I_1}^{I_1^*} \frac{\partial}{\partial I_1}\Gamma(t, I_2^*)dt \\ &= \Gamma(I_1^*, I_2^*) - \Gamma(I_1, I_2^*) \geq 0,\end{aligned}$$

which shows that I_1^* is indeed a best response for Division 1. That completes the proof of Proposition 2.

The additive separability assumption (A3) ensures that a single instrument can satisfy the incentive compatibility constraints of both divisions simultaneously. We may interpret the revenue and cost functions in (A3) as second order approximations of the "true" valuation functions. That is, if one considers a second order Taylor expansion of $C(\cdot)$ around some point (q^0, θ^0, I_1^0) then the resulting second order polynomials always satisfy (A3). Consistent with the intuition developed in figure 2, we conclude that a system of negotiated transfer pricing, which allows for renegotiation, will provide at least an approximate solution to the bilateral investment problem.

The message of Proposition 2 is that renegotiation of simple fixed-price contracts can induce efficient investment. Moreover, the desired prior quantity $\bar{q}$ is invariant to changes in γ. Intuitively, one might think that Division 1's willingness to invest decreases as γ decreases. However, consider equation (8). As γ decreases, Division 1's share of the ultimate gains from trade, i.e., $M(\theta, I)$, decreases. But at the same time, Division 2 retains a larger share of the reduction in cost to produce $\bar{q}$. The corresponding term is $(1-\gamma)\cdot C(\bar{q}, \theta, I)$. If $\bar{q}$ is chosen according to (9), the two effects cancel each other precisely.

It is instructive to compare our findings with Chung (1991). In his model, the parties also sign a fixed-price contract at date 1. In addition, they contractually agree on a particular renegotiation process at date 4, in which one side makes a take-it-or-leave-it offer. This corresponds to a situation where $\gamma = 0$ or $\gamma = 1$. Chung finds that even without the separability assumption (A3) it is then possible to choose a prior quantity $\bar{q}$ so that both parties will undertake efficient investments. For instance, when $\gamma = 0$, Division 2 will obviously have the desired incentive since it receives the entire renegotiation surplus and, therefore, the full return from its specific investment. In contrast, Division 1's incentives are not affected by the expected renegotiation outcome. It anticipates that it will be held to its status quo payoff, and therefore it chooses I_1 so as to maximize $-E_\theta\,[C(\bar{q}, \theta, I_1)] - I_1$. Chung (1991) shows that under "mild" conditions there exists a $\bar{q}$ such that $-E_\theta\,[C(\bar{q}, \theta, I_1)] - I_1$ is maximized at I_1^*.

Though Chung's analysis establishes an exact solution to the bilateral investment problem without assumption (A3), we have concerns about the implementability of his solution. The equilibrium incentives of Chung's mechanism rely crucially on the assumption that if Division 1 rejects Division 2's take-it-or-leave-it offer at date 4, there will be no further negotiation. To make such a policy credible, H.Q. would have to monitor the process and prevent the divisions from trading the intermediate product in the foreseeable future, once Division 1 has rejected the other division's offer. Such interference appears costly and impractical in most environments.

Propositions 1 and 2 above have relied on the fact that the quantity choice q is continuous. Rogerson (1984) considers a situation where the separability assumption (A3) is satisfied and an

indivisible good can either be traded or not, i.e., $q \in \{0, 1\}$. Rogerson finds that a prior agreement of $\bar{q} = 0$ will induce underinvestment while $\bar{q} = 1$ leads to overinvestment. This conclusion is consistent with Proposition 2 since $\bar{q} = 1$ exceeds $E_\theta [q^*(\theta, I^*)]$. To obtain efficient investments with a binary quantity set, the prior agreement at date 1 has to involve some randomization.[11]

The foregoing analysis has simply assumed that the parties adopt the γ-surplus sharing rule in their negotiations. Bargaining theory has shown that the same outcomes can also be obtained as non-cooperative equilibria of a game in which the players alternate in making offers. Suppose that at date 4 the manager of Division 2 first proposes an outcome (q, t). Division 1 can accept or reject the offer. If it rejects the offer, Division 1 proposes an outcome in the second round, which Division 2 can accept or reject. The game proceeds in this manner; Division 2 makes offers in odd- and Division 1 in even-numbered rounds.

To impose discipline on the negotiating process, suppose there is an arbitrarily small but positive probability, ε, that the game terminates whenever an offer is rejected. This chance of breakdown may reflect that a manager may be irritated by the other's refusal. Alternatively, managers may have to attend to other matters, and therefore cannot continue in the bargaining process. If the game terminates without agreement at any stage, the parties abide by the status quo outcome.[12] Myerson (1991, Theorem 8.3) shows that this alternating offers game has a unique subgame-perfect equilibrium, in which Division 2's first offer is accepted by Division 1. The equilibrium transfer payment varies with ε; as ε approaches zero the equilibrium transfer payment approaches the value that corresponds to $\gamma = .5$.

Myerson's (1991) result suggests that one can obtain a purely non-cooperative version of Proposition 2. Given assumptions (A1)–(A3), suppose that division managers play the alternating offers game at dates 1 and 4. The resulting game has a subgame perfect equilibrium with the following properties: in the first round of the date 1 bargaining process the parties agree to a pair $(\bar{q}, \bar{t})$ with $\bar{q} = E_\theta\{q^*(\theta, I_1^*, I_2^*)\}$. Subsequently, they choose the efficient investments I_1^* and I_2^*, respectively. Finally, the first offer of the date 4 bargaining process is accepted leading to the transfer $q^*(\theta, I_1^*, I_2^*)$.[13]

IV. MORAL HAZARD AND DIVISIONAL PERFORMANCE EVALUATION

In the model presented thus far, divisional managers take no actions that impose personal costs on them. Nonetheless, it was assumed that each divisional manager maximizes his/her division's expected income. While the latter specification seems descriptive, one may object that in the current model it would have been easier to give divisional managers a share of total firm profits. H.Q. could then simply instruct managers to make investment and quantity transfer decisions in the firm's overall best interest, instead of the divisional interests.

In this section, we expand the model to include moral hazard on the part of divisional managers. As described in section II, the two divisions are assumed to operate in separate markets except for the intermediate product in question. Let x_i denote operating income for Division i resulting from "external operations," i.e., from transactions that do not involve the other division.

[11] For instance, the parties could sign a contract which stipulates that with probability p there will be a transfer ($\bar{q} = 1$) at date 1, while with probability $(1-p)$ there will be no transfer. Given (A3) and $p = E_\theta[q^*(\theta, I^*)]$, Proposition 2 continues to hold.

[12] Rather than appeal to a small exogenous probability of negotiation breakdown, one may alternatively postulate that the parties discount agreements reached in later rounds. This model has been studied by Rubinstein (1982); see also Myerson (1991).

[13] See Edlin and Reichelstein (1994) for a formal analysis of this model.

Suppose the manager of Division i can increase x_i by taking actions that are personally costly. For the purpose of performance evaluation, H.Q. can observe only the aggregate operating results:

$$z_2 = x_2 + R(q, \theta, I_2) - I$$
$$z_1 = x_1 - C(q, \theta, I_1) - I_1$$

This situation reflects "account fungibility;" H.Q. cannot identify whether a dollar in cost was incurred to support the intermediate product (transferred to Division 2) or to support another externally sold product. Given the transfer payment t, the divisional income figures become:

$$\Pi_1 = z_1 + t \text{ and } \Pi_2 = z_2 - t.$$

At the beginning of the period (and prior to contracting) each division manager receives private information, represented by a one-dimensional variable, t_i. The realized value of x_i is assumed to depend on t_i and on the manager's unobservable actions. Let $D_i(x_i, t_i)$ denote the personal cost manager i bears, if he/she wants to attain external operating income x_i in state t_i. As usual, this cost represents the disutility of managerial effort or the utility foregone when discretionary expenses are reduced.

When divisional managers also take actions that are personally costly, H.Q. faces a combined managerial incentive and intrafirm resource allocation problem. Our main finding is that this problem can effectively be decomposed: H.Q. selects suitable compensation schemes based on divisional income for each of the managers and adopts a policy of negotiated transfer pricing. Earlier literature has shown that under certain conditions linear incentive schemes are optimal for agency problems with asymmetric information and risk neutral agents. We note that the results of section III above apply without change if at date 0 the manager of Division i were given a compensation scheme of the form $\alpha_i \cdot \Pi_i + \beta_i$, where $0 < \alpha_i < 1$ represents a bonus parameter.

If the manager of Division i seeks to maximize the expected value of $\alpha_i \cdot \Pi_i$, the outcome of γ-surplus sharing is unaffected by the value of α_i. In fact, for the Nash bargaining solution this is true by definition, since one of the axioms underlying the Nash solution is that the bargaining outcome is unchanged if either party's utility is scaled by a constant factor.[14] If one takes a non-cooperative approach to bargaining and considers, for instance, the alternating offers game described in section III, it is also obvious that any equilibrium outcome for given (α_1, α_2) will remain an equilibrium if the α_i's change.

To describe the sequence of events, suppose the timeline of figure 1 is extended to the left, as shown in figure 3. At date -2, the division managers receive their private information τ_i. It is public knowledge that $\tau_i \in [\underline{\tau}_i, \overline{\tau}_i]$, and that the prior probability distribution of τ_i is $F_i(\tau_i)$, with density $f_i(\tau_i)$. At date -1, H.Q. proposes a contract to the division managers, and at date 0, the managers report their private information to H.Q.

Suppose that at date -1 H.Q. offers each manager a menu of compensation functions, each linear in divisional income. Thus, H.Q. commits to three functions $\left\{\beta_i(\tau_i), \alpha_i(\tau_i), \overline{\Pi}_i(\tau_i)\right\}_{\tau_i \in [\underline{\tau}_i, \overline{\tau}_i]}$, specifying a fixed salary β_i, a bonus parameter α_i, and a target level for divisional income $\overline{\Pi}_i$. If the manager of Division i reports τ_i, his/her compensation scheme becomes:

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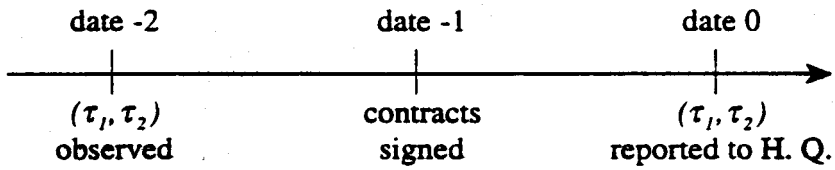
[14] Intuitively, it may appear that the renegotiation surplus increases as the α_i's increase. This would be true if the divisional managers could make direct side payments to each other. In our model, however, they can only transfer divisional income, which translates into personal income at the rate α_i.

FIGURE 3



$$\beta_i(\tau_i) + \alpha_i(\tau_i) \cdot \left[\Pi_i - \overline{\Pi}_i(\tau_i)\right]. \tag{12}$$

The bonus parameters $\alpha_i(\cdot)$ are chosen so as to provide divisional managers with appropriate performance incentives with respect to x_i. The target profits $\overline{\Pi}_i(\tau_i)$ are equal to the expected value of Π_i so that the expected "budget variance" in (12) is zero. As a consequence, $\beta_i(\tau_i)$ becomes the manager's expected compensation. Its magnitude is given by some exogenous market constraint, which we normalize to zero, without loss of generality. Because of their private information, managers will earn informational rents. Given the assumptions stated below, these rents will be decreasing in τ_i. Thus, $\beta_i(\tau_i)$ is decreasing with $\beta_i(\overline{\tau}_i) = 0$. The exact functional forms for the triplet $\{\beta_i(\cdot), \alpha_i(\cdot), \overline{\Pi}_i(\cdot)\}$ are given in the proof of Proposition 3 (appendix). We refer to this triplet as a *proper* menu of linear compensation schemes.

Following the approach of Melumad et al. (1992), and Vaysman (1994a), we invoke the following assumptions to ensure the optimality of a menu of linear incentive schemes.[15]

(A4) $D_i(x_i, \tau_i) = b_i(\tau_i) \cdot d_i(x_i)$. Both $b_i(\cdot)$ and $d_i(\cdot)$ are positive, differentiable, increasing and convex.

(A5) The ratio $\frac{F_i(\tau_i)}{f_i(\tau_i)} \cdot \frac{b_i'(\tau_i)}{b_i(\tau_i)}$ is increasing in τ_i.

The multiplicative separability assumption in (A4) implies that higher types τ_i face a uniformly higher cost of achieving external operating income x_i. The convexity conditions ensure in particular that the cost functions satisfy the familiar *single-crossing* property. Assumption (A5) modifies the usual *monotone inverse hazard rate* condition, which requires that $\frac{F_i(\tau_i)}{f_i(\tau_i)}$ be increasing in τ_i.

The firm's net-profit is given by the sum of the divisional operating "cash flows" minus the compensation paid to divisional managers. To find an optimal mechanism, H.Q. could design a (Bayesian) incentive compatible revelation mechanism. Such a mechanism would be rather complex since divisional managers would be asked to report information at date 0 regarding τ_i and at date 3 regarding θ. H.Q. would have to specify policies for investment and intrafirm transfers based on the reports obtained. The resulting revelation mechanism would obviously involve more instructions and more reporting to H.Q. than the decentralized mechanism described above.

Proposition 3: Given assumptions (A1)–(A5), a proper menu of linear compensation schemes for each divisional manager combined with a policy of negotiated transfer pricing maximizes the firm's net profit among all incentive compatible mechanisms.

[15] Laffont and Tirole (1986), Kanodia (1993) and others have also analyzed settings in which menus of linear contracts are optimal. In their analysis, the cost functions $C_i(x_i, \tau_i)$ are additively separable in x_i and τ_i rather than multiplicatively separable as in (A4).

In the proof of Proposition 3 (see appendix), we consider a benchmark problem which would result if H.Q. could actually observe the specific investments and the state θ at date 3. We demonstrate that a proper menu of linear compensation schemes combined with negotiated transfer pricing achieves the same expected net-profit as the optimal revelation mechanism for the benchmark problem. The intuition is straightforward in light of Proposition 2 above. Independent of the bonus parameters determined at date 0, the division managers will, in equilibrium, choose first-best investments and intracompany transfers. At date 0, the contributions to divisional income from internal transactions, i.e., $R(q, \theta, I_2) - I_2 - t$ and $t - C(q, \theta, I_1) - I_1$, are effectively viewed as noise terms. All parties have identical knowledge about these two random variables, including their expected values. Because of risk neutrality and the linearity of the incentive schemes, the presence of a noise term has no effect on managers' behavior.

For the mechanism we have described, each divisional manager has a "strong" incentive to report truthfully at date 0 since the bonus parameter he will receive is independent of the other manager's report. Truthful reporting is not quite a dominant strategy, however, since the manager of Division j could tie his specific investment decision I_j at date 2 to the value of α_i resulting from i's reporting at date 0. Of course, the manager of Division j has no incentive to adopt such a strategy since the outcome of the transfer pricing negotiation is independent of the bonus parameters.

It follows from Propositon 3 that for the purpose of performance evaluation it is sufficient to look at aggregate divisional income. Although H.Q. could disaggregate Π_i into operating results and transfer payment (i.e., into z_i and t), Proposition 3 shows that divisional managers will have the desired incentives, if z_i and t receive the same weight in their incentive schemes.

V. CONCLUDING REMARKS

This paper has analyzed a system of negotiated transfer pricing in which divisions can agree on a simple fixed-price contract and renegotiate this contract on arrival of better information. Such arrangements are sufficient to provide each division manager with the incentive to make upfront investments that are in the entire firm's interest. Moreover, when the divisional managers are subject to moral hazard, it is possible to solve the resulting incentive and resource allocation problem in a decentralized manner: managers are evaluated on the basis of divisional income and the divisions negotiate the transfer payment associated with interdivisional trade.

Our analysis points to the importance of allowing divisional managers to renegotiate prior agreements upon the arrival of new information. Furthermore, it is essential that each manager perceives that he/she could insist that the prior contract be fulfilled. For select firms, Meurer (1993) and Shelanski (1993) indicate that central management imposes such a specific performance rule when divisional managers seek to "get out" of intra-company agreements. Future empirical research on transfer pricing could provide further evidence on the use of the specific performance rule.

While our results support the common use of negotiated transfer pricing, it is also natural to ask why many firms prefer alternative rules of transfer pricing. First, our model neglects the cost of "haggling," which is frequently mentioned as a drawback of negotiated transfer pricing. The cost of bargaining may be particularly relevant when there are more than two divisions involved. For instance, the fixed cost incurred by the upstream division may benefit several downstream divisions. A negotiated system would then require some form of multilateral bargaining or a series of bilateral negotiations.

We recall that the results of this paper hinge on the assumption that division managers have symmetric information about revenues and costs in their bilateral negotiations. Bargaining theory

suggests that with incomplete information the equilibrium outcome will generally not be efficient. An administered transfer pricing policy may partially overcome these inefficiencies.

Holmstrom and Tirole (1991) point out that it may be difficult to sign a prior contract because the good to be transferred cannot be specified at the outset. The usual hold-up argument then applies and the parties will underinvest. It is conceivable that some cost-based transfer pricing rule may ameliorate the underinvestment problem. On the other hand, if the cost-based rule is administered by H.Q., and not subject to renegotiation, it may lead to quantity transfers that are ex-post inefficient. As a consequence, there may be a tradeoff between ex-ante incentives for investment and ex-post allocative efficiency.

APPENDIX

Proof of Proposition 1: Suppose $I_1 \in \hat{I}_1(\bar{q}, I_2)$ and $\tilde{I}_1 \in \hat{I}_1(\bar{q} + \Delta\bar{q}, I_2 + \Delta I_2)$, where $\Delta\bar{q} > 0$ and $\Delta I_2 \geq 0$. We establish the claim that $\tilde{I}_1 > I_1$ in two steps. We first consider any $I_1^* = \min\{\hat{I}_1(\bar{q} + \Delta\bar{q}, I_2)\}$ and show that $I_1^* > I_1$. The second step then shows that $I_1^* \leq \tilde{I}_1$.

By definition, $\Gamma_1(I_1, I_2, \bar{q}) \geq \Gamma_1(I_1^*, I_2, \bar{q})$ and $\Gamma_1(I_1^*, I_2, \bar{q} + \Delta\bar{q}) \geq \Gamma_1(I_1, I_2, \bar{q} + \Delta\bar{q})$. Adding these inequalities, we obtain

$$\Gamma_1(I_1^*, I_2, \bar{q} + \Delta\bar{q}) - \Gamma_1(I_1, I_2, \bar{q} + \Delta\bar{q}) - [\Gamma_1(I_1^*, I_2, \bar{q}) - \Gamma_1(I_1, I_2, \bar{q})] \geq 0. \qquad (i)$$

The left-hand side of (*i*) is equal to:

$$\int_{\bar{q}}^{\bar{q}+\Delta\bar{q}} \int_{I_1}^{I_1^*} \frac{\partial^2}{\partial\bar{q}\partial I_1} \Gamma_1(u, I_2, v)\,du\,dv. \qquad (ii)$$

From equation (7) we obtain that

$$\frac{\partial^2}{\partial\bar{q}\partial I_1} \Gamma_1(u, I_2, v) = -(1-\gamma)\cdot E_\theta\left\{\frac{\partial^2}{\partial q \partial I_1} C(v, \theta, u)\right\}. \qquad (iii)$$

By assumption (A1), the right-hand side of (*iii*) is positive. Therefore the integrand in (*ii*) is positive, and since the value of the integral must be non-negative, it follows that $I_1^* \geq I_1$. It cannot be true that $I_1^* = I_1$, since that would imply $\frac{\partial}{\partial I_1}\Gamma_1(I_1, I_2, \bar{q}) = 0 = \frac{\partial}{\partial I_1}\Gamma_1(I_1, I_2, \bar{q} + \Delta\bar{q})$, contradicting assumption (A1). Therefore $I_1^* > I_1$.

When $\Delta I_2 = 0$, it follows from the definition of I_1^o that $I_1^o \leq \tilde{I}_1$. To show this inequality when $\Delta I_2 > 0$, we adopt the same sequence of arguments, noting that

$$\frac{\partial^2}{\partial I_1 \partial I_2} \Gamma_1(u, v, \bar{q} + \Delta\bar{q}) = \gamma \cdot E_\theta\left\{\frac{\partial^2}{\partial q \partial I_2} R(q^*(\theta, u, v), \theta, v) \cdot \frac{\partial}{\partial I_1} q^*(\theta, u, v)\right\} > 0.$$

Finally, if $\Delta\bar{q} = 0$ but $\Delta I_2 > 0$, we can establish along the same lines that $\tilde{I}_1 > I_1$, using again the fact that $\frac{\partial^2}{\partial I_1 \partial I_2}\Gamma_1(u, v, \bar{q}) > 0$. That completes the proof of Proposition 1.

Proof of Propositon 3: Consider first the following benchmark problem: H.Q. observes x_i directly, and I, q and θ as well. To prove the claim, we establish in Step 1 the solution to the benchmark problem. We then show in Step 2 that suitable linear incentive schemes combined with negotiated transfer pricing lead to the same expected net-profit as in the benchmark problem.

Step 1: Under the benchmark problem, H.Q. offers the manager of Division *i* a contract of the form $\{x_i(\tau_i), H_i(\tau_i)\}$. If manager *i* reports τ_i, he/she must deliver $x_i(\tau_i)$ and is paid $H_i(\tau_i)$. Suppose each

manager's reservation utility is normalized to zero. It can then be shown with standard techniques that any incentive compatible mechanism has to satisfy:

$$H_i(\tau_i) = D_i(x_i(\tau_i), \tau_i) + \int_{\tau_i}^{\bar{\tau}_i} \frac{\partial}{\partial \tau_i} D_i(x_i(y), y)dy. \qquad (i)$$

Furthermore:

$$E_{\tau_i}\left[H_i(\tau_i)\right] = E_{\tau_i}\left[\left(b_i(\tau_i) + \frac{F_i(\tau_i)}{f_i(\tau_i)} b_i'(\tau_i)\right) \cdot d_i(x_i(\tau_i))\right]$$

Equation (*ii*) makes use of the multiplicative separability assumption (A1). The right-hand side of (*ii*) is the expected "virtual" cost (true cost plus informational rent), which varies with the policy $x_i(\tau_i)$. The optimal policy $x_i^*(\cdot)$ is the one that maximizes (pointwise) the difference between profit contribution and payment to the manager, i.e.,

$$x_i^*(\tau_i) \in \underset{x_i}{\operatorname{argmax}} \left\{ x_i - \left(b_i(\tau_i) + \frac{F_i(\tau_i)}{f_i(\tau_i)} b_i'(\tau_i) \right) d_i(x_i) \right\}.$$

For notational brevity, let $E_{\tau_i}[H_i^*(\tau_i)]$ represent the right-hand side of (*ii*) evaluated at an optimal policy $x_i^*(\tau_i)$. It follows that the maximum net-profit attainable under the benchmark scenario is given by:

$$E_{\tau}\left[\sum_{i=1}^{2}\left(x_i^*(\tau_i) - H_i^*(\tau_i)\right)\right] + E_\theta\left[M(\theta, I^*)\right] - I_1^* - I_2^*.$$

Step 2: We construct a menu of linear incentive schemes based on divisional income and then verify that the resulting net-profit achieves the upper bound given by (*iv*). Specifically, define the functions $\alpha_i(\tau_i)$, $\beta_i(\tau_i)$ and $\overline{\Pi}_i(\tau_i)$ as follows:

$$\alpha_i(\tau_i) = \frac{1}{1 + \frac{F_i(\tau_i)}{f_i(\tau_i)} \cdot \frac{b_i'(\tau_i)}{b_i(\tau_i)}} \qquad (v)$$

$$\beta_i(\tau_i) = b_i(\tau_i \quad d_i(x_i^*(\tau_i)) + \int_{\tau_i}^{\bar{\tau}_i} b_i'(y) \cdot d_i(x_i^*(y))dy$$

$$\overline{\Pi}_2(\tau_2) = x_2^*(\tau_2) + E_\theta\left[R(q^*(\theta, I^*), \theta, I_2^*) - t_\gamma(\theta, I^*)\right] - I_2^* \qquad (vii)$$

$$\overline{\Pi}_1(\tau_1) = x_1^*(\tau_1) + E_\theta\left[t_\gamma(\theta, I^* \quad - C(q^*(\theta, I^*), \theta, I_1^*)\right] - I_1^*. \qquad (viii)$$

Here, $t_\gamma(\theta, I^*)$ denotes the final transfer price that results at date 4 under the γ-surplus sharing rule if the state is θ. Suppose each division manager reports τ_i truthfully at date 0. Subsequently, each will choose x_i so as to maximize $\alpha_i(\tau_i) \cdot x_i - b_i(\tau_i) \cdot d_i(x_i)$. Inspection of (*v*) shows that the optimal choice is indeed $x_i^*(\tau_i)$. The expected compensation payment for manager i is given by:

$$E_\theta\left[\alpha_i(\tau_i) \cdot (\Pi_i - \overline{\Pi}_i(\tau_i))\right] + \beta_i(\tau_i).$$

By Proposition 2, the divisions will implement I^* and $q^*(\theta, I^*)$ if they adopt the γ-surplus sharing rule. Furthermore, the transfer price will be $t_\gamma(\theta, I^*)$ in state θ. Hence the expected contributions to divisional income from internal operations are the respective expressions on the right-hand side of (*vii*) and (*viii*). It follows that $E_\theta[\alpha_i(\tau_i) \cdot (\Pi_i - \overline{\Pi}_i(\tau_i))] = 0$. By construction of (*vi*), $\beta_i(\tau_i) = H_i^*(\tau_i)$; therefore, the expected compensation for each manager matches the compensation paid in the benchmark problem.

To complete the proof, one needs to check that the menu of contracts given by (*v*)-(*viii*) is indeed globally incentive compatible. By assumption (A5), the bonus parameters $\alpha_i(\cdot)$ are decreasing in τ_i, i.e., lower cost types receive larger bonus parameters. This property is necessary for incentive compatibility. For the remaining details of the argument, see a similar proof in Melumad et al. (1992).

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