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Transfer Pricing Based on Actual versus Standard Costs

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1 Introduction

Recent research on transfer pricing has discovered the interplay between short-run and long-run incentives as one of its core questions. This paper contributes to this line of research and investigates cost-based transfer prices more closely. The importance of the question is obvious. International surveys show that cost-based transfer prices are used by 40 to 50 percent of the firms.[1] Managerial accounting education knows two approaches, actual-cost based and standard-cost based transfer prices. The aim of this paper is to compare investment and trade incentives that arise under the two respective regimes.

The basic difference between the two regimes is the different use of available information. To quote from Horngren, Foster, and Datar (2000, 225)

> "[...] A standard is a carefully predetermined price, cost, or quantity amount. [...] The advantages of standards are as follows: (i) they can exclude past inefficiencies, and (ii) they can take into account changes expected to occur in the budget period."

Following this definition, a standard is determined at an early stage of the decision process. Moreover, it has benchmark properties. As such, there must be a commitment for not changing the standard ex post. Therefore a standard does not depend on information that arrives after the standard-setting stage. To the contrary, no such commitment is incurred when actual cost information is used.

We consider a scenario where the central office determines the transfer pricing regime at the outset. Then, a selling and a buying division must incur relation-specific investment into cost reduction or revenue enhancement prior to the resolution of uncertainty and the subsequent trade decision. The firm thus faces the dangers behind the famous 'hold-up problem' (Williamson, 1985). Our question

[1] See Vancil (1978) or Coenenberg (1992).

then is how actual-cost and standard-cost based transfer prices perform in this setting.

We first clarify to which extent the optimal transfer price includes a mark-up over marginal costs under either regime. For transfer prices based on actual costs there is an intuitive trade-off. Without mark-up there is no incentive for cost-reduction investments by the selling division. This is because an actual-cost based transfer price is only fixed after the investment stage and after uncertainty has been resolved. Thus, if the transfer price equals unit variable costs, there is no marginal return on investment.[2] On the other hand, mark-ups erode the trade decision.[3] The optimal mark-up should balance these two inefficiencies.

If the central office decides to use standard costs it commits to forego the available cost information. This may turn out to be beneficial. As the transfer price is fixed before the investment stage, the selling division receives full marginal return on cost-reduction investment. Thus, there will be no investment distortion. This advantage is confronted with a strong efficiency loss concerning the trade decision, however. This is because actual-cost based transfer prices will react to the state of the world and thus allow for an adjustment of the trade decision to the true marginal cost of the firm. If standard costs are used, the central office commits to ignore information about marginal costs. The best the firm's headquarters can do under such a commitment is to choose the transfer price such that it induces trade of the expected efficient quantity. Standard-cost based transfer prices should therefore equal *expected* marginal cost.

The commitment to ignore information about actual costs becomes critical if cost uncertainty is high. Then, actual costs dominate standard costs. On the other hand, standard costs tend to be better than actual costs if investments into cost reduction and/or revenue enhancement are urgent, that is, if the marginal

[2] This result is derived in Sahay (1997). The verbal tradition, however, goes back at least to Schmalenbach (1908/09).

[3] Thus, for situations without investment, the classic rule is to set the transfer price equal to marginal cost. See Hirshleifer (1956).

returns on investment are high.

Our paper fits in recent literature on transfer pricing and investment incentives. There are two strands. First, there is a *mechanism-design approach.* Papers of this strand look for an optimal mechanism given the assumed informational deficits. The typical main question then is whether there exists some transfer-pricing mechanism that induces the first best solution.[4,5] Other papers belonging to this class derive impossibility results for the attainability of a first-best solution.[6] The problem behind the mechanism-design approach is that the resulting mechanisms are not necessarily used in business practice.

A second strand of the literature looks at transfer-pricing mechanisms that are not necessarily optimal but used in business practice. This line of research is called *comparative analysis approach.* Our paper belongs to this class. Typical research papers take two or more candidate transfer-pricing regimes and investigate under which circumstances one regime dominates another.[7] Previous research has looked at comparisons between negotiated and cost-based transfer pricing (Baldenius, Reichelstein, and Sahay (1999) (BRS henceforth) and Pfeiffer (2002)), or market-based transfer pricing and the role of the arm's length principle.[8]

[4] The issue has been raised by Hart and Moore (1988). Subsequently, Aghion, Dewatripont, and Rey (1994), Nöldecke and Schmidt (1995), and Böckem and Schiller (2003) show how so-called option contracts provide an answer to the problem. Edlin and Reichelstein (1995, 1996) show how fixed-quantity contracts with renegotiation solve the same problem. This mechanism seems more robust than an option contract as the efficiency result is independent of the parties' bargaining power. Fixed quantity contracts with renegotiation also prove powerful in extensions to the problem like Wielenberg (2000) or Böckem and Schiller (2004).

[5] In an asymmetric information setting Vaysman (1996) shows that a decentralized transfer-pricing mechanism may be superior to a centralized mechanism if the revelation principle is violated.

[6] Impossibility results typically occur if there is an investment externality. See MacLeod and Malcomson (1993) or Che and Hausch (1999).

[7] The main body of the literature investigates these questions in a framework of symmetric information. Wagenhofer (1994) and Baldenius (2000) assume an asymmetric-information framework. Anctil and Dutta (1999) investigate a somewhat different question. These authors analyze managerial performance evaluation that may rely on the transfer-pricing system or may be firm wide.

[8] See Baldenius and Reichelstein (2002). The issue is further explored in papers that relate managerial issues on transfer pricing to tax issues. See Baldenius, Melumad, and Reichelstein (2004) and Korn and Lengsfeld (2003).

Our paper is related to BRS (1999) and Pfeiffer (2002). BRS investigate the trade-off between negotiated and (decentralized) standard-cost based transfer pricing. In addition, Pfeiffer (2002) also analyzes actual costs. Our paper differs from those two by the notion of 'standard costs'. In BRS (1999) and Pfeiffer (2002) a divisional manager sends a (biased) bottom-up message about his costs *after* uncertainty has resolved. In our setting the firm's headquarters defines standard costs *before* uncertainty is resolved. Thus, BRS and Pfeiffer assume a decentralized setting whereas ours is centralized. We aim to compare the performance of 'standard costs' in our sense to 'actual-costs' where, in the latter regime, headquarters observes the ex-post realization of marginal cost but commits to a mark-up at the ex-ante stage.[9]

Finally, our paper is related to companion work by Lengsfeld and Vogt (2003). Instead of selfish investment Lengsfeld and Vogt consider cross investments, i.e. the upstream division (intra-firm selling division) invests into revenue enhancement instead of cost reduction.

The remainder of the paper is organized as follows. Section 2 introduces the model. Then, sections 3 and 4 analyze the two respective transfer pricing regimes. The characterization of the central trade-off is in section 5. Some conclusions follow.

2 The Model

Consider a firm that consists of two divisions, $i = 1, 2$, and Headquarters (HQ henceforth). Division 1 is the producer who sells a quantity q of some intermediate good to division 2. Division 2 is the sales department that sells a final good to

[9] The latter scenario is identical to Pfeiffer (2002). Another important difference between Pfeiffer's work and ours is that we study the impact of investment productivities on the relative advantage of actual-cost based transfer pricing. In Pfeiffer (2002) there are no comparative statics with respect to investment productivities.

the market. Normalize quantity measurement such that q measures both, the quantity of the intermediate and the final good.

Before the good is traded, division 1 incurs costs of $C(q, \theta, I_1)$ where θ is the realization of a (multidimensional) random variable and I_1 is division 1's (physical) investment into cost reduction. Think of I_1 as a process innovation. Let the associated investment cost be given by $w(I_1) = (I_1)^2/2$. We assume

$$C(q, \theta, I_1) = (c(\theta) - yI_1)q$$

where $c(\theta)$ is the level of some initial marginal cost that depends on the random state of the world. Marginal cost can be reduced by the amount yI_1 where $y > 0$ is the productivity of investment I_1. Assume that the distribution of $\tilde{\theta}$ is common knowledge. Let $\bar{c}$ be the expected value of $c(\tilde{\theta})$ and $\sigma_c^2 \equiv var\{c(\tilde{\theta})\}$.

Division 2 orders a quantity q from division 1. We assume that HQ is committed to enforce this quantity decision. Before division 2 places its order it invests I_2 into revenue enhancement. Think of I_2 as an investment into higher product quality or as a marketing campaign. Let the associated cost of investment be $w(I_2) = (I_2)^2/2$. Let p be the final good's market price and assume an inverse demand function of the form

$$p(q, I_2) = a + xI_2 - \frac{b}{2} \cdot q$$

where, $a, b > 0$. I_2 raises the price by the amount xI_2. Thus, $x > 0$ measures the productivity of revenue enhancing investment. Division 2's revenue is given by

$$R(q, I_2) = (a + xI_2 - \frac{b}{2} \cdot q) \cdot q.$$

Each division is run by a risk-neutral manager who aims at maximizing the profit of his own division. Divisional profits depend on transfer payments. Let t denote the transfer price. Divisional payoffs then are

$$\Pi_1 = tq - C(q, \theta, I_1) - \frac{(I_1)^2}{2} \qquad \text{and} \qquad \Pi_2 = R(q, I_2) - tq + \rho(\theta) - \frac{(I_2)^2}{2}.$$

The expression $\rho(\theta)$ in division 2's profit function is a state-dependent revenue from trade with other products. Without loss of generality we assume that $E\{\rho(\tilde{\theta})\} = 0$.

There is symmetric information among the divisions at each decision stage but asymmetric information between the divisions and HQ. HQ can neither observe the chosen investment levels nor the realized θ. Moreover, we assume that the accounting system only records the sum $R(q, I_2) + \rho(\theta)$. This fact may be due to the allocation of customer-specific rebates to either R or ρ in the accounting system of division 2. Therefore, the investment levels I_1, I_2 cannot be contracted upon directly.[10] We assume, however, that HQ has implemented a cost accounting system and can observe actual marginal cost $c(\theta) - yI_1$ and the transferred quantity q. Thus, the transfer-pricing system can be based on actual marginal cost. This access to information sets HQ into the position to announce an actual-cost based transfer price, t_A.[11] We define t_A by

$$t_A = c(\theta) - yI_1 + m_A$$

where m_A is a markup over marginal cost chosen by HQ.[12]

In the above transfer-pricing regime HQ's makes use of the actual cost information. Alternatively, it can also commit to ignore it. Then, the transfer price can only depend on expected cost. In that case, HQ sets a standard-cost based transfer price t_S. To keep the exposition between the two transfer-pricing systems symmetric the reader may think of t_S as $t_S = \bar{c} - yI_1^S + m_S$ where I_1^S denotes the anticipated subgame-perfect level of division 1's investment choice and m_S is the markup over expected marginal cost.[13]

[10] Alternatively, we could assume state-depending parameters $a(\theta)$ and $b(\theta)$ (as in Pfeiffer (2002)). Such a set-up would also prevent HQ from contracting upon I_2 directly. The alternative setting would not affect the intuition behind any of our results but extend the necessary algebra.

[11] In what follows, the subscripts A and S refer to the the actual-cost based and standard-cost based transfer pricing regime, respectively.

[12] Sahay (1997) shows that additive markups are superior to multiplicative markups. Therefore, we ignore the latter.

[13] >From a formal point of view, what matters is that t_S does not depend on the actual values

The timing of the game is shown in figure 1. At stage 0, HQ announces whether a standard-cost based or an actual-cost-based transfer price will be used. If the transfer pricing rule follows standard costs, HQ announces t_S immediately. If HQ decides to use an actual-cost based regime, it announces the mark-up m_A. At stage 1, the divisions invest I_i $(i = 1, 2)$. Then, at stage 2, the state of nature is realized. Immediately thereafter HQ and the divisions observe marginal cost. If an actual-cost based transfer price is used, t_A is fixed now. Afterwards, division 2 orders a quantity q_j, $j \in \{A, S\}$. This quantity is sold to the market at stage 3. Finally, all payoffs are realized.

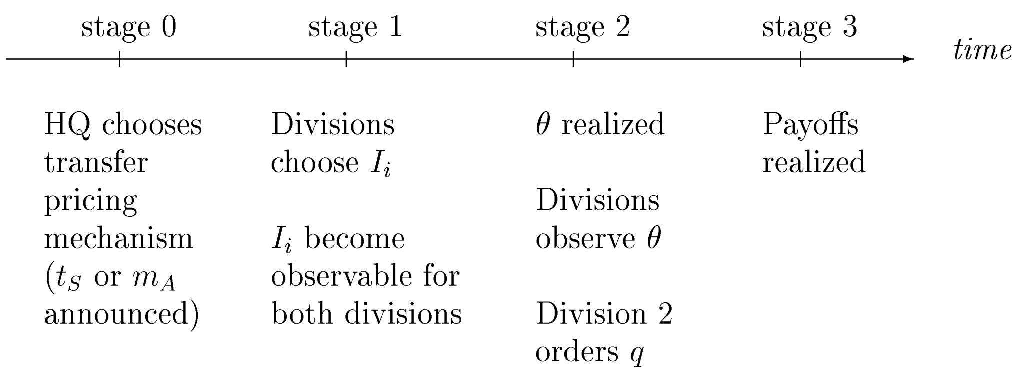

Figure 1: Time line

In order to ensure existence of the first-best solution and of a subgame-perfect equilibrium under the both transfer-pricing modes, we place the following assumption.

Assumption 1 *Let* $b > x^2 + y^2$, $\bar{c} \in (ay^2/(b - x^2), a)$ *and* $\sup_\theta c(\theta) < a$.

Assumption 1 is merely technical. It ensures that the following maximization problems are well behaved and the solutions are interior. The assumption thus excludes trivial cases.

of θ and I_1. We will show later that $m_S = 0$ is optimal from HQ's perspective.

Before we proceed with the analysis, let us describe the first-best solution as a benchmark. Given any investment levels $I = (I_1, I_2)$ the efficient quantity maximizes the joint contribution M at stage 2, i.e.

$$M(q, \theta, I) = \left[a + xI_2 - \frac{b}{2}q - (c(\theta) - yI_1)\right] \cdot q + \rho(\theta)$$

with respect to q. As a result, the efficient quantity $q^{eff}(\theta, I)$ is given by

$$q^{eff}(\theta, I) = \frac{a - c(\theta) + yI_1 + x\, I_2}{b}. \tag{1}$$

For any θ the third part of assumption 1 ensures that the efficient trade level is positive.

Efficient investment levels maximize expected joint profit at stage 1, given the efficient trade rule, that is, they solve[14]

$$\max_{I_1, I_2} \qquad E\left\{M(q^{eff}(\theta, I), \theta, I)\right\} - \sum_{i=1}^{2} w(I_i).$$

Take the respective partial derivatives with respect to I_i $(i = 1, 2)$ and apply the Envelope Theorem. We end up with

$$I_1 \;=\; y \cdot E\{q^{eff}\} = y \cdot \frac{a - \bar{c} + yI_1 + x\, I_2}{b} \tag{2}$$

$$I_2 \;=\; x \cdot E\{q^{eff}\} = x \cdot \frac{a - \bar{c} + yI_1 + xI_2}{b}. \tag{3}$$

The first-best investment levels I_i^{FB} $(i = 1, 2)$ are given by the solution to the above two equations. Resubstituting the investment levels gives the first-best trade level and expected first-best joint profit. The result is stated in the following proposition.

[14] In what follows $E\{\cdot\}$ denotes that expectation is taken over θ.

Proposition 1 *The first-best quantity q^{FB}, the first-best investment levels I_i^{FB} $(i = 1, 2)$, and the expected first-best joint profit $E\{\Pi^{FB}\}$ are given by*

$$
\begin{aligned}
q^{FB} &= \frac{a - c(\theta) + \frac{(y^2+x^2)\,(a-\bar{c})}{b-x^2-y^2}}{b}, \\
I_1^{FB} &= y \cdot \frac{a - \bar{c}}{b - x^2 - y^2}, \\
I_2^{FB} &= x \cdot \frac{a - \bar{c}}{b - x^2 - y^2}, \\
E\{\Pi^{FB}\} &= \frac{(a - \bar{c})^2}{2\,(b - x^2 - y^2)} + \frac{\sigma_c^2}{2\,b}. \qquad (4)
\end{aligned}
$$

Proof. All proofs are in the appendix.

The variance expression in equation (4) is of special significance. It enters expected firm profit because the quantity decision is adjusted to actual marginal costs rather than letting the quantity decision be based on expected marginal costs. Therefore, $\sigma_c^2/2\,b$ can be interpreted as the option value of adjusting the trade decision to actual marginal costs, $c(\theta)$.

3 Transfer Pricing Based on Actual Costs

In this section we investigate the non-cooperative game if HQ has chosen to use actual-cost based transfer pricing. For any (θ, I_1) the transfer price is fixed at stage 2 of the game and given by

$$t_A = c(\theta) - yI_1 + m_A.$$

Expected divisional profits thus read

$$\Pi_1^A = E\Big\{t_A\, q - (c(\theta) - yI_1) \cdot q\Big\} - w(I_1) \qquad (5)$$

$$\Pi_2^A = E\left\{(a - \frac{1}{2}\, b\, q + x\, I_2) \cdot q - t\, q\right\} - w(I_2). \qquad (6)$$

We solve the game by backward induction. Division 2's quantity decision is taken after investments (I_1, I_2) have been chosen and after θ has been drawn. Division 2 maximizes the short-run contribution $R(q, I_2) - t_A q$ with respect to q. The quantity-decision rule is given by

$$q^A(\theta, I, m_A) = \frac{a - c(\theta) + yI_1 + x\,I_2 - m_A}{b} = q^{eff}(\theta, I) - \frac{m_A}{b}. \tag{7}$$

Equation (7) reveals that the mark-up m_A leads to a trade distortion.[15] This result is well known at least since Hirshleifer's (1956) classic paper. With a positive mark-up, the buying division faces a higher price for the intermediate good. Thus, it reduces the trade volume compared to the first-best quantity until marginal revenue equals marginal costs, i.e., the transfer price.

Continuing with backward induction consider stage 1. Both divisional managers simultaneously choose their investment levels anticipating the quantity-decision rule $q^A(\theta, I, m_A)$. Maximizing (5) and (6) leads to the following individually optimal investment levels

$$I_1(m_A) = y\,\frac{m_A}{b}, \tag{8}$$

$$I_2(m_A) = x\;E\{q^A(\theta, I)\}. \tag{9}$$

What is the effect of the mark-up m_A on the economic decisions? Comparison of the individual investment decision $I_2(m_A)$ with the efficient rule shows that division 2 selects I_2 efficiently, conditional on the expected quantity choice. Thus, the investment level I_2 is only indirectly affected by HQ's choice of the mark-up m_A via the trade distortion. To the contrary, investment I_1 is obviously affected by m_A in a *direct* manner as it equals $y{\cdot}m_A/b$. Finally, the quantity q^A is distorted by the mark-up twice. First, there is a direct effect from equation (7). Second, there is an indirect effect that is transmitted via the distorted investment level $I_1(m_A)$.

[15] For a mark-up $m_A = 0$ the traded quantity q^A is ex-post efficient but misses the first-best level q^{FB}. This is because I_1 will be chosen equal to zero. See the result below.

Intuitively spoken, the mark-up should be neither too high nor too low. First, if there is no mark-up, the seller does not invest at all while the buyer invests efficiently. Second, higher mark-ups erode the trade level and subsequently the buyer's investment decision. However, third, a higher mark-up increase the seller's investment. The trade-off between the first two effects and the third leads to a second-best result that is stated in Proposition 2.

Proposition 2 *For the actual-cost based regime, the optimal mark-up over actual marginal cost is given by*

$$m_A^* = \frac{by^2(a-\bar{c})}{b^2 + y^2(b - x^2 - y^2)} > 0. \tag{10}$$

The quantity $q^A(m_A^*)$ *and the investment levels in the subgame-perfect equilibrium are given by*

$$\begin{aligned} q^A(m_A^*) &= \frac{a - c(\theta)}{b} + \frac{(a-\bar{c})[x^2(b^2 + y^2(b - x^2 - y^2)) - y^2 b(b - y^2)]}{b(b - x^2)(b^2 + y^2(b - x^2 - y^2))} \\ I_1^A(m_A^*) &= \frac{y^3(a-\bar{c})}{b^2 + y^2(b - x^2 - y^2)} \\ I_2^A(m_A^*) &= \frac{x\,(a-\bar{c})\,(b^2 - x^2y^2)}{(b - x^2)\,(b^2 + y^2(b - x^2 - y^2))}. \end{aligned}$$

Expected firm profit is given by

$$E\{\Pi^A\} = \frac{(a-\bar{c})^2}{2\,(b - x^2 - y^2)} \cdot H^A + \frac{\sigma_c^2}{2\,b} \tag{11}$$

where H^A *is defined as*

$$H^A \equiv \frac{(b - x^2 - y^2)(b^2 + y^2(b - x^2))}{(b - x^2)(b^2 + y^2(b - x^2 - y^2))} \in (0, 1). \tag{12}$$

The firm's profit as given in equation (11) differs from the first-best profit (see equation (4)) by the expression $H^A \in (0, 1)$. We conclude that the firm's expected profit is strictly positive, but strictly lower than in the first-best world. It is important to note that the option value of trade adjustment, $\sigma_c^2/2b$, will be fully attained in the actual-cost based regime. The reason for missing the expected first-best profit is the distortion of the investment and trade levels.

4 Transfer Pricing Based on Standard Costs

In contrast to transfer prices based on actual cost, a standard-cost based transfer price t_S is already fixed at stage 0. That is, information about the state of the world θ cannot enter the transfer-pricing rule and, hence, the trade decision. It is immediate that the trade decision will be inefficient unless, by coincidence, t_S equals actual marginal cost. Generally spoken, there will be under-trade in those states of the world where t_S exceeds marginal cost and over-trade in the other cases. If t_S is lower than the actual marginal cost, division 1 will make an operating loss. Our transfer-pricing system requires that trade is enforced in those states of the world.

The subsequent analysis proves the following intuition: With a standard-cost based transfer price, divisions will face a fixed-price contract. As such, the seller and the buyer will receive full marginal return on investment into cost reduction and revenue enhancement, respectively. Therefore, there will be efficient investment. This result is independent of the precise level of t_S. Thus, t_S remains as a degree of freedom in order to provide trade incentives. Generically, there will be inefficient trade as t_S is fixed before the realization of θ. The best HQ can do at stage 0 is to minimize expected trade distortions. Thus, given the separability properties of our revenue and cost functions, HQ should set t_S such that the trade level equals the efficient quantity in expectation.

To show this we first solve for the optimal quantity decision given any (t_S, I, θ). At stage 2 the buyer's profit is

$$[a + xI_2 - \frac{b}{2} \cdot q] \cdot q - t_S \cdot q + \rho(\theta)$$

which is maximized if

$$q^S(I, t_S) = \frac{a + xI_2 - t_S}{b} = q^{eff}(\theta, I) - \frac{t_S - (c(\theta) - yI_1)}{b}.$$

Taking expectations, we see that our above intuition will be justified if we can show that the optimal transfer price t_S^* equals expected marginal cost, given the first-best investment level, i.e. if

$$t_S^* = \overline{c} - y\, I_1^{FB}.$$

This is confirmed by Proposition 3.

Proposition 3 *Under standard-cost-based transfer prices HQ sets the optimal transfer price equal to*

$$t_S^* = \frac{\overline{c}(b - x^2) - ay^2}{b - x^2 - y^2} = \overline{c} - yI_1^{FB}.$$

Given this transfer price, equilibrium-investment levels are equal to their respective first-best values

$$\begin{aligned} I_1^S(t_S^*) &= I_1^{FB} \\ I_2^S(t_S^*) &= I_2^{FB}. \end{aligned}$$

Given these decisions, the firm's expected profit is

$$E\{\Pi^S\} = \frac{(a - \overline{c})^2}{2(b - x^2 - y^2)} = E\{\Pi^{FB}\} - \frac{\sigma_c^2}{2b}. \tag{13}$$

The optimal mark-up is $m_S = 0$, i.e. the optimal transfer price fits what conventional definitions know as a 'standard marginal cost': Standard costs are predetermined and assume efficient economic behavior (here, efficient investment into cost reduction).

An important property of standard-cost based transfer prices is that they induce investment levels that are equal to their first-best value. This result is not surprising from a theoretical point of view. As is well known, fixed-price contracts are a powerful device to set investment incentives.

Our result has another implication. The contribution margin of division 1 equals zero in expectation, i.e. the division will make a loss of $-w(I_1^{FB})$ on average. Thus, our system of transfer prices needs to be accompanied by an investment-budgeting process where the selling division obtains an investment budget of $w(I_1^{FB})$. Otherwise, divisional manager 1 would strongly be against the use of a standard-cost based transfer pricing system at stage 0.[16]

Proposition 3 finally shows that expected firm profit differs from first-best profit by the variance expression $\sigma_c^2/2b$. This difference just reflects the loss of the option value arising from a postponed trade decision.

Remark. It is interesting to have a closer look at the relation between standard-cost based transfer pricing and fixed-quantity contracts with renegotiation in the sense of Edlin and Reichelstein (1995, 1996). Edlin and Reichelstein propose a transfer-pricing mechanism that fixes a default quantity $\overline{q}$ at stage 0 and allows for renegotiation of the initial trade decision after θ has become known. In such a setting the first-best solution is attainable if the cost and revenue functions satisfy a separability condition.[17] The initial quantity $\overline{q}$ must be set equal to the expected efficient level, $\overline{q} = E\{q^{eff}\}$. Later it will be renegotiated such that the actual-traded quantity is efficient in each state of nature.

Standard cost-based transfer prices work quite similarly. By setting the transfer price equal to expected marginal cost at its efficient investment level, the quantity is fixed to $E\{q^{eff}\}$. The main difference is that the standard-cost based transfer-pricing mechanism does not allow for an ex-post adjustment of the quantity. Therefore, the option value $\sigma_c^2/2b$ is forgone and the first-best profit is missed.

[16] See Pfeiffer and Schneider (2003) for a model where transfer prices are complemented by investment budgets if there is asymmetric information.

[17] The cost and revenue functions in our model belong to the class described by Edlin and Reichelstein's separability assumption.

5 Comparison Between the Two Regimes

The advantages and disadvantages of the two regimes can now be easily compared. The disadvantages of transfer pricing based on actual costs are given by the induced distortions of the investment levels and the traded quantity. In contrast, the disadvantage of standard-cost based transfer pricing is given by the foregone option value $\sigma_c^2/2b$. Therefore, HQ should favor transfer prices based on actual (standard) costs if the variability of $c(\theta)$ is relatively high (low). This is confirmed by the following proposition.

Proposition 4 *For any given vector of parameters* $(a, \overline{c}, x, b)$*, actual-cost based transfer prices dominate standard-cost based transfer prices if and only if* σ_c^2 *exceeds the critical threshold* $\overline{\sigma}_c^2$*, given by*

$$\overline{\sigma}_c^2 = \frac{b^3\, y^2\, (a-\bar{c})^2}{(b-x^2)(b-x^2-y^2)(b^2+y^2(b-x^2-y^2))}.$$

This critical threshold is increasing in the pre-investment margin $(a-\overline{c})$. The impacts of the demand parameter b and the investment-productivity parameters x and y are less easy to see. Nevertheless, we can state following result.

Proposition 5 *The threshold* $\overline{\sigma}_c^2$ *is increasing in* $(a-\overline{c})$*, increasing in the productivities of investment,* x *and* y *and decreasing in* b*.*

Proposition 5 reflects the fact that transfer pricing based on actual cost has two implications on the trade level. First, there is the mark-up m_A that distorts trade *on average*. Second, the trade level reacts to the realization of $c(\theta)$. Therefore, the option value of adjusting the trade decision will be gained. On the other hand, standard-cost based transfer pricing leads to an unbiased average trade level, but forgoes the option value. As the latter is proportional to the variance σ_c^2 and the 'average importance of trade' is measured by $(a-\overline{c})$, the critical threshold $\overline{\sigma}_c^2$ must be increasing in $(a-\overline{c})$.

The second result ($\overline{\sigma}_c^2$ is increasing in x and y) follows a similar intuition. Investments are distorted under actual-cost based transfer pricing, but equal to their first-best levels if standard costs are used. Since an increase in x and y makes correct investment decisions more important, an increase in the productivities of investment will be offset only by an increase of cost uncertainty, σ_c^2. In other words, if producitivites increase, investment efficiency becomes urgent. Therefore, the range of uncertainty for which standard-cost based transfer pricing is favorable increases as well.

The impact of the demand-curve slope b on the threshold value is a little more complex to see. Consider the benchmark case first. In the first-best world, the optimal sales price remains unaffected by a decrease of b. A one-percent reduction of b thus leads to a one-percent rise of the optimal quantity. Moreover, a decrease in b increases the return on investment for both, I_1 and I_2. Thus, a decreasing b makes investment more important. Therefore, there will be a unique *investment-incentive effect* of a reduction in b. Since standard-cost based transfer prices ensure efficient investment, this regime becomes more favorable relative to actual-cost based transfer pricing. A decreasing b also has a *quantity effect*. Fortunately, the latter points into the same direction as the investment effect. Taking the partial differentiation with respect to b yields

$$\frac{\partial m_A^*}{\partial b} = -\frac{y^2(a-\overline{c})(b^2+y^2(x^2+y^2))}{(b^2+y^2(b-x^2-y^2))^2} < 0,$$

A decrease in b leads to an increase of the optimal mark-up m_A Thus, a declining b increases trade distortion in the actual-cost based regime and makes the standard-cost based regime more favorable.

6 An Example

This section develops a simple example in order to illustrate the trade-off between the two transfer-pricing regimes. Assume that $c(\theta)$ is uniformly distributed over the interval $[\bar{c}-\delta, \bar{c}+\delta]$. This implies

$$\sigma_c^2 = \int_{\bar{c}-\delta}^{\bar{c}+\delta} \frac{c^2}{2\delta} dc - \bar{c}^2 = \frac{\delta^2}{3}.$$

To ensure interior solutions we restrict parameters to the following range.

$$\begin{array}{lll} a = 12, & \bar{c} \in [2,4], & \delta \in (0,2) \\ b \in [10,\infty), & x, y \in [0,2) & \end{array}$$

The variance is therefore restricted to the interval $\sigma_c^2 \in (0, 4/3)$.

Figure 2 depicts graphs of the threshold $\overline{\sigma}_c^2$ depending on the parameters of the model. Above the threshold, HQ should choose actual-cost based transfer pricing. Below $\overline{\sigma}_c^2$, transfer prices based on standard costs are more favorable.[18]

The upper left diagram in figure 2 shows that the threshold depends much stronger on the productivity y than x. Our formal analysis helps understanding this asymmetry. Investment I_1 is distorted directly under actual-based transfer pricing but undistorted in the standard-cost based transfer pricing regime. Thus, $\overline{\sigma}_c$ reacts 'strongly' on changes in y. On the other hand, I_2 is chosen efficiently, conditional on the quantity choice under the actual-cost based regime. That is, the distortion is only indirect. Therefore, $\overline{\sigma}_c$ reacts 'weakly' to changes in x.

7 Conclusion

The paper has shown under which circumstances actual-cost based transfer prices are more favorable than those based on standard costs, and vice versa.

We summarize our above results in terms of ex-ante versus ex-post efficiency. Standard-cost based transfer prices are a powerful device to set ex-ante incentives. We have shown that the investment levels equal their first-best values, and trade equals its expected efficient level. However, standard-cost based transfer prices

[18] The flat areas in figure 2 are due to the restriction of σ_c^2.

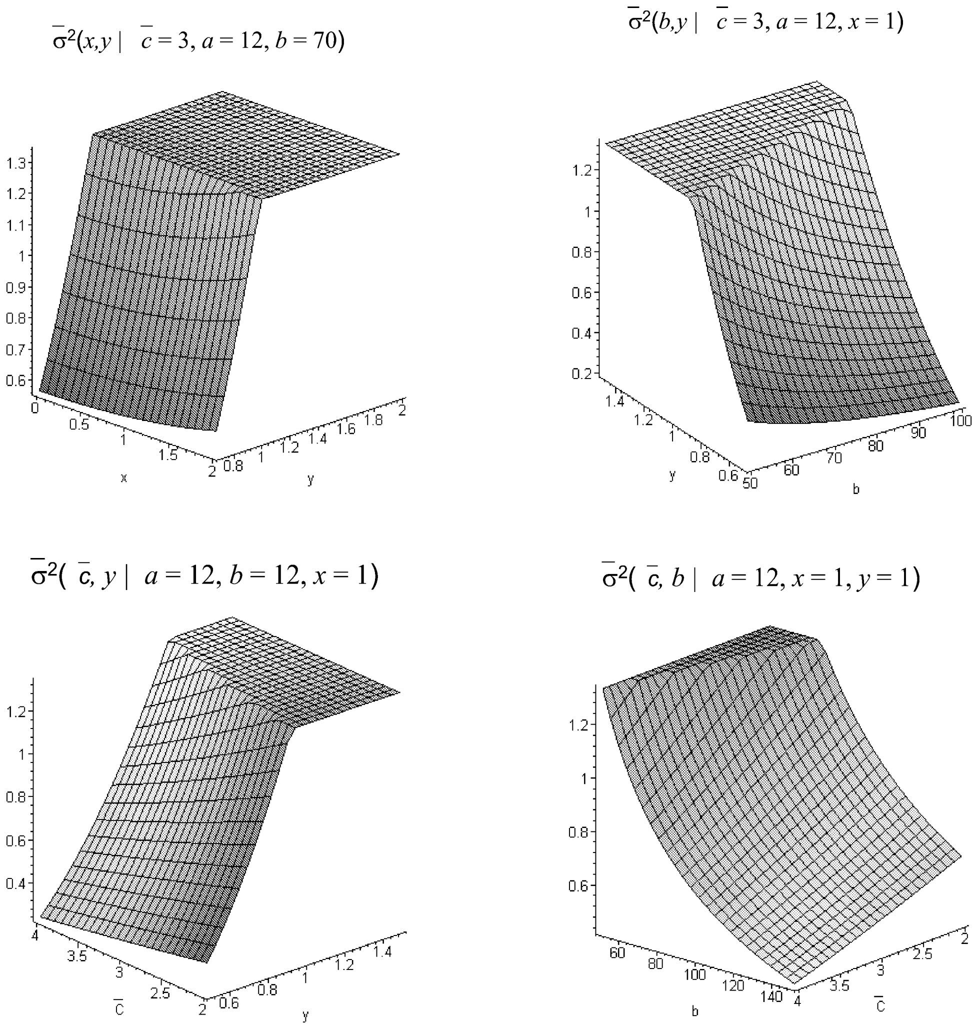

Figure 2: The threshold $\overline{\sigma}_c^2$

do not react to ex-post information by definition. That is, the realization of the production costs are not considered in the trade decision. Therefore, an option value of trade adjustment is foregone.

With actual-cost based transfer prices the option value of trade adjustment is preserved. It is, however, suboptimal to induce the efficient trade level. This is because HQ must commit to a mark-up over actual marginal cost before investment decisions are made. Otherwise, the selling division would have no incentives for cost-reduction investments. The optimal mark-up trades off investment and trade incentives. Therefore, both the investment levels and the trade level will be distorted.

Which transfer pricing system is preferable depends on the degree of cost uncertainty, the shape of the inverse demand function, and the productivities of investments. The higher the uncertainty, the more important an ex-post trade adjustment is, and the more favorable are transfer prices based on actual costs. The higher the average contribution margin or the higher the producitivities of cost-reducing or revenue-enhancing investments, the more urgent efficient ex-ante investments are. Therefore, standard-cost based transfer prices may perform better.

Cost accounting literature has sometimes made the point that if the costing system transmits more information, management would be enabled to make better decisions. Like many of its predecessors in information economics, our analysis has shown that this is not generally true. Although a standard costing system carries less information than an actual-cost based system, the first may turn out to be superior to the latter.

Appendix

Proof of Proposition 1. Solving the equations (2) and (3) gives I_i^{FB} $(i = 1, 2)$. Resubstitute the result into (1) to obtain q^{FB}. Notice that assumption 1 is sufficient for strict concavity of the maximization problems.

Now substitute the results into the firm's expected profit function. This yields

$$\begin{aligned} E\{\Pi^{FB}\} &= E\left\{\left(a - \frac{b}{2}\,q^{FB} + x\,I_1^{FB}\right) \cdot q^{FB} - (c(\theta) - yI_2^{FB}) \cdot q^{FB}\right\} - \sum_{i=1}^{2} w(I_i^{FB}) \\ &= \frac{E\{c(\theta)^2\}(b - x^2 - y^2) + \bar{c}^2(y^2 + x^2) - 2ab\bar{c} + a^2 b}{2b(b - x^2 - y^2)} \\ &= \frac{(a - \bar{c})^2}{2\,(b - x^2 - y^2)} + \frac{\sigma_c^2}{2\,b}. \end{aligned}$$

Proof of Proposition 2. At the investment stage, each division maximizes expected profit (see (5) and (6)) anticipating the quantity-decision rule $q^A(\cdot)$ of equation (7). Taking the respective first-order conditions and using the envelope theorem shows that investment levels are chosen according to (8) and (9) (the first part of assumption 1 ensures strict concavity). Now, solve (9) for I_2 and substitute (8) into the result. The solution then is

$$I_1^A(m_A) = y\,\frac{m_A}{b} \qquad I_2^A(m_A) = x\,\frac{b(a - \bar{c}) - m_A(b - y^2)}{b(b - x^2)}$$

Inserting these investment levels into the quantity-decision rule and collecting terms gives $q_A(\theta, m_A) = \frac{b(a - c(\theta)) + x^2(c(\theta) - \bar{c}) - m_A(b - y^2)}{b(b - x^2)}$. The optimal m_A maximizes expected firm profit given by

$$E\{[a + xI_2^A(m_A) - \frac{b}{2}\,q^A(\theta, m_A)]\,q^A(\theta, m_A) - [c(\theta) - y\,I_1^A(m_A)]\,q^A(\theta, m_A)\} - \sum_{i=1}^{2} w(I_i^A(m_A)).$$

Insert the expressions for $q^A(\theta, m_A)$ and $I_i(m_A)$ $(i = 1, 2)$ set the first derivative with respect to m_A equal to zero and apply the envelope theorem. Some algebraic manipulations finally reveal that the optimal mark-up m_A^* is given by (10). Then, re-substitute (10) into (7), (8), and (9) and re-calculate the firm's expected profit. This gives

$$\begin{aligned} E\{\Pi^A\} &= \frac{1}{2\,b\,[b^2+y^2\,(b-x^2-y^2)]\,[b-x^2]} \cdot \\ &\quad \Big(E\{c(\theta)^2\}\cdot(b^3+y^2b^2-x^2b^2-2x^2y^2b-by^4+y^2x^4+y^4x^2) \\ &\quad + \bar{c}^2(x^2b^2+by^4+by^2x^2-y^2x^4-y^4x^2) \\ &\quad - 2b^3a\bar{c}+b^3a^2+b^2a^2y^2-2b^2y^2a\bar{c}+2y^2x^2ba\bar{c}-by^2x^2a^2\Big) \\ &= \frac{\sigma_c^2}{2\,b} + \frac{(a-\bar{c})^2(b^3+y^2b^2-by^2x^2)}{2\,b\,(b^2+b^2y^2-x^2y^2-y^4)\,(b-x^2)} \\ &= \frac{(a-\bar{c})^2}{2\,(b-x^2-y^2)} \cdot \frac{(b-x^2-y^2)(b^2+by^2-y^2x^2)}{(b^2+y^2\,(b-x^2-y^2))(b-x^2)} + \frac{\sigma_c^2}{2b} \\ &= \frac{(a-\bar{c})^2}{2\,(b-x^2-y^2)} \cdot H^A + \frac{\sigma_c^2}{2\,b}. \end{aligned}$$

To see that $H^A \in (0,1)$ notice first that by assumption 1 any of the factors in (12) is positive. After rewriting the expression as

$$H^A = \frac{b^3 - x^2\,b^2 - by^4 - 2\,x^2y^2b + x^4y^2 + x^2y^4}{b^3 - x^2\,b^2 - by^4 - 2\,x^2y^2\,b + x^4y^2 + x^2y^4 + b^2y^2} \tag{14}$$

it is also easy to see that $H^A < 1$.

Proof of Proposition 3. Substituting the quantity rule $q^S(I, t_S)$ into the expected profit functions for divisions 1 and 2 and taking the first partial derivatives with respect to I_1 and I_2 yields as best-response functions

$$\begin{aligned} I_1 &= y \cdot q^S(I, t_S) = y \cdot \frac{a + xI_2 - t_S}{b} \\ I_2 &= x \cdot q^S(I, t_S) = x \cdot \frac{a + xI_2 - t_S}{b}. \end{aligned}$$

This gives the equilibrium values

$$\begin{aligned} I_1^S(t_S) &= y \cdot \frac{a - t_S}{b - x^2} \\ I_2^S(t_S) &= x \cdot \frac{a - t_S}{b - x^2}. \end{aligned}$$

Now re-substitute $q^S(I, t_S)$ and $I_1^S(t_S), I_2^S(t_S)$ into the firm's expected profit function and maximize with respect to t_S gives the optimal transfer price t_S^*. Given our assumption 1 a unique $t_S^* > 0$ exists and equals

$$t_S^* = \frac{\overline{c}(b - x^2) - ay^2}{b - x^2 - y^2} = \overline{c} - yI_1^{FB}.$$

Finally, insert the optimal transfer price into $I_1^S(t_S)$ and $I_2^S(t_S)$ to see that the equilibrium investment levels equal their first-best values.

Proof of Proposition 4. Actual-cost based transfer prices should be chosen if and only if

$$\frac{(a-\bar{c})^2}{2\,(b-x^2-y^2)} \leq \frac{(a-\bar{c})^2}{2\,(b-x^2-y^2)} \cdot H^A + \frac{\sigma_c^2}{2\,b}$$

$$\text{or} \qquad \sigma_c^2 \geq \frac{2\,b\,(a-\bar{c})^2}{2\,(b-x^2-y^2)} \cdot (1 - \underbrace{\frac{(b-x^2-y^2)(b^2+y^2(b-x^2))}{(b-x^2)(b^2+y^2b-x^2y^2-y^4)}}_{H^A})$$

After some algebraic manipulations this gives

$$\sigma_c^2 \geq \overline{\sigma}_c^2 = \frac{b^3\,y^2\,(a-\bar{c})^2}{(b-x^2)(b-x^2-y^2)(b^2+y^2(b-x^2-y^2))}.$$

Proof of Proposition 5. The first statement is obvious. To show the second take the derivative of $\overline{\sigma}_c^2$ with respect to b. This gives

$$\frac{\partial \overline{\sigma}_c^2}{\partial b} = -\,b^2y^2\,(a-\bar{c})^2 \cdot \frac{[b^4+2x^2y^2b^2+2y^4b^2-x^4b^2-8x^2y^4b-6x^4y^2b-2y^6b+6x^4y^4+3x^6y^2+3y^6x^2]}{[(b-x^2)(b-x^2-y^2)(b^2+y^2(b-x^2-y^2))]^2}.$$

The sign depends on the expression in squared brackets. The latter can be rewritten as

$$\begin{aligned}
&[b^4+2x^2y^2b^2+2y^4b^2-x^4b^2-8x^2y^4b-6x^4y^2b-2y^6b+6x^4y^4+3x^6y^2+3y^6x^2] \\
&= \underbrace{(b-x^2-y^2)}_{(I)}\underbrace{(b^3+(x^2+y^2)b^2}_{(II)} + \underbrace{(4x^2y^2+3y^4)b+y^6-x^2y^4-2x^4y^2)}_{(III)} \\
&\quad \underbrace{+y^8+3x^2y^6+3x^4y^4+x^6y^2}_{(IV)}.
\end{aligned}$$

Expressions (I), (II), and (IV) are positive. To see the sign of expression (III) observe that by assumption 1

$$\begin{aligned}&(4x^2y^2+3y^4)b+y^6-x^2y^4-2x^4y^2>\\&\quad(4x^2y^2+3y^4)(x^2+y^2)+y^6-x^2y^4-2x^4y^2=\\&\quad 2x^4y^2+6x^2y^4+4y^6>0.\end{aligned}$$

Thus, $\partial\overline{\sigma}_c^2/\partial b<0$.

For the third statement, take the derivatives with respect to x and y. Start with x to obtain

$$\frac{\partial\overline{\sigma}_c^2}{\partial x}=\frac{\left[2b^3-6bx^2y^2-4by^4-2x^2b^2+3x^4y^2+4x^2y^4+y^6+2y^2b^2\right]2b^3xy^2\left(a-\bar{c}\right)^2}{\left(\left(b-x^2-y^2\right)\left(b-x^2\right)\left(b^2+by^2-x^2y^2-y^4\right)\right)^2}.$$

Again, the sign depends on the expression in squared brackets. Using the same trick as before, rewrite this term as

$$\begin{aligned}&[2b^3-6bx^2y^2-4by^4-2x^2b^2+3x^4y^2+4x^2y^4+y^6+2y^2b^2]\\&\quad=\underbrace{[b-x^2-y^2]}_{(I')}\cdot\underbrace{[2b^2+4by^2-2x^2y^2]}_{(II')}+\underbrace{y^2x^4+2x^2y^4+y^6}_{(III')}.\end{aligned}$$

Expressions (I') and (III') are positive. For the sign of expression (II') observe that due to the first part of assumption 1 $2(b^2+2by^2-x^2y^2)>b^2+2y^2(x^2+y^2)-x^2y^2=b^2+x^2y^2+2y^4>0$. Thus, $\partial\overline{\sigma}_c^2/\partial x>0$.

Finally, take the derivative with respect to y.

$$\frac{\partial\overline{\sigma}_c^2}{\partial y}=\frac{2yb^3(a-\overline{c})^2[b^3+2by^4-x^2b^2-2x^2y^4-2y^6]}{((b-x^2)(b-x^2-y^2)(-b^2-y^2b+y^2x^2+y^4))^2}.$$

Observe that $b^3+2by^4-x^2b^2-2x^2y^4-2y^6>b^2(x^2+y^2)+2(x^2+y^2)y^4-x^2b^2-2x^2y^4-2y^6=y^2b^2>0$. Therefore, $\partial\overline{\sigma}_c^2/\partial y>0$. □

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