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THE TRANSFER PRICING PROBLEM:  
WHERE THE PROFITS ARE

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## 1. Introduction.

There is currently a great deal of interest in the United States and elsewhere in revising the regulations that govern the taxation of multinational corporations. This interest arises in part from the perception that large integrated firms avoid taxes by manipulating the transfer prices used for trade between their own affiliates located in countries with different tax rates. Academic researchers consistently find indirect but strong evidence of transfer price manipulation under current rules,<sup>1</sup> and the scope of the potential problem is quite large, since more than a quarter of all US merchandise exports are shipments from American parent companies to their majority-owned affiliates abroad.<sup>2</sup>

The design of transfer price regulations runs squarely into the problem that even in theory it is sometimes unclear which of a firm's affiliates are properly credited with earning a firm's profits. The challenge is to construct a system that provides efficient incentives for resource allocation by integrated international firms while preserving the location (for tax purposes) of purely national profits. This paper offers a general solution to this problem, based partly on the observation that, in competitive markets, assets earning what appear ex post to be pure rents may in fact have been

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<sup>1</sup>See, for example, Jenkins and Wright (1975), Kopits (1976), Bernard and Weiner (1990), Hines and Rice (1990), and Grubert and Mutti (forthcoming).

<sup>2</sup>In 1986 total US merchandise exports were \$224 billion; of these, \$59 billion were exported by US parent corporations to their own majority-owned foreign affiliates (Whichard, 1988). The fraction of total exports accounted for by within-firm transactions appears to be gradually rising over time. In addition, there are two reasons why published statistics are likely to understate the volume of within-firm trade: first, they do not include within-firm transactions of *foreign-owned* firms that export from the United States; second, they represent only reported magnitudes - given the historically high relative tax rates in the US, firms generally faced incentives to understate the value of exports to foreign affiliates.

produced by firms that ex ante earned only normal returns.

Section 2 of this paper describes the transfer pricing problem and some solutions that have been proposed in the past. Section 3 offers a different solution and demonstrates that it supports an efficient allocation of resources. Section 4 briefly discusses some of the complications that arise in practice, analyzes methods governments have employed to address this problem, and argues that the solution corresponds to concepts of income division that governments have tried to employ in broader contexts.

## 2. The Problem and Some Solutions.

The central problem raised by transfer pricing can be illustrated by a simple example. Suppose an American electronics firm produces a unique type of computer (with special color graphics) in California, and sells the computers in Germany. The firm's German marketing arm has unique skills in marketing the computers with color graphics there, and the firm makes significant overall profits. The transfer pricing problem is: what part of the firm's profits originate in California, and what part in Germany? Since the German tax rate (50%) is significantly higher than the US tax rate (34%), the firm naturally prefers to earn its profits in the US,<sup>3</sup> and can do so if allowed to sell the computers from California to its German subsidiary for a high transfer price. The problem only increases in complexity when the

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<sup>3</sup>Except under somewhat unusual circumstances. Since the United States operates a worldwide corporate income tax, the firm is eligible for foreign tax credits on taxes paid to the German government; if the firm has lightly taxed foreign income that can be averaged with German income for purposes of the foreign tax credit calculation, then the tax payment to Germany simply offsets US taxes that would otherwise have been due. In a similar vein, manipulating transfer prices to declare profits in low-tax foreign locations does not help firms that do not exploit deferral and are in deficit foreign tax credit positions. But most US multinationals do, in fact, benefit by avoiding foreign taxes; for evidence and a discussion of optimal tax-avoiding strategies, see Hines and Rice (1990).

California firm later establishes a second foreign affiliate, in Singapore, to produce some of the computers.

American law requires firms to use arm's-length prices for international transactions between related parties; the arm's-length principle is also the standard for the OECD model double taxation treaty and most national tax systems.<sup>4</sup> Arm's-length prices are market prices, the prices that unrelated parties (those that transact at "arm's length") would use; in the example of the computer firm, the arm's-length principle would require the California firm to sell the computers to the German affiliate at market prices. One difficulty in its application is that if arm's-length prices cannot be observed (because goods are unique) they may be difficult to infer: the California affiliate and the German affiliate if they were unrelated firms would represent bilateral monopolists that might transact at any price within a continuum.<sup>5</sup> Another difficulty is that market prices may not be relevant to transactions between related parties. One of the major reasons that firms integrate their operations across national boundaries is that they prefer not

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<sup>4</sup>Of the 25 industrialized countries surveyed in Lawlor (1985), 24 applied the arm's-length principle to taxation of related-party transactions; Hong Kong was the exception. US law (§ 482 of the Internal Revenue Code) provides three alternative methods of determining transfer prices for related-party transactions when arm's-length prices are unavailable; as Berry (1989) observes, these alternatives represent approximations to arm's-length prices based on information that is incomplete in one form or another.

<sup>5</sup>Blair and Kaserman (1987) offer a partial resolution of the problem of choosing efficient ex post contract terms for transactions between bilateral monopolists producing perfectly complementary goods: they argue that bilateral monopolists will agree to a fixed (indeterminate) division of total profits. The solution presented here in section 3 represents, for the case they examine, a determinate division of total profits that yields efficient ex ante incentives; and more generally, it offers solutions over a complete domain of production technologies.

to use market prices to guide their transactions.<sup>6</sup> Indeed, given the double taxation that many multinationals face, the decision to integrate operations often makes sense only if intrafirm economies can be exploited (or if taxes can be avoided through transfer price schemes).

Much of the academic literature on transfer pricing concerns the efficient design of transfer prices used to decentralize the operations of different branches of the same firm; these prices are usually linear by assumption. When applied to the international context, it is sometimes argued that these decentralizing prices are appropriate for taxing profits earned in different countries. Hirshleifer (1956) and Gould (1964) establish in models with no uncertainty that efficiently decentralized transfer prices equal shadow values - marginal revenue products - of traded intermediate goods. Diewert (1985) identifies five different linear price schemes that generalize this finding, distinguishing prices that provide efficient decentralized incentives from those that firms would choose to maximize after-tax profits under a variety of restrictions.

By concentrating on the marginal incentive effects of transfer prices, these models sidestep the important question of the division of inframarginal profit between centers. Simply pricing intermediate goods at their marginal products is not feasible for some production technologies, since with nonconstant returns to scale the sum of affiliates' attributed profits will not equal total firm profits.<sup>7</sup> Another aspect of the same problem is that

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<sup>6</sup>See, for example, Caves (1982, p. 195), who argues that "The multinational enterprise's rationale...lies in its prowess at evading the failures of certain arm's-length markets, especially those for intangible assets."

<sup>7</sup>This feature is known in the legal literature as "the continuum price problem" as in Langbein (1986).

the distribution of firm profits under marginal product pricing may depend rather arbitrarily on which affiliate is considered to be the selling center and which the buying.

Hart and Mas-Colell (1988, 1989) propose an alternative method of profit attribution based on Shapley values. Their concept is that the contribution of an affiliate to firm profit potential is properly measured by the extent to which profits would fall in the absence of the affiliate. Such a measure is consistent with profit measurement for independent firms, and also (they prove) has the feature that the level of aggregation does not affect the distribution of profits, subject to keeping the number of profit centers constant. But their method of allocating profits appears to be too sensitive to the number of affiliates. If each affiliate produces unique inputs that are perfectly complementary in production of the final good, then Shapley values divide final profits evenly among all the affiliates. This implies, then, that a legal merger of two affiliates reduces their share of the firm's profits, even though the merger has no real consequences.

This troubling implication of Hart and Mas-Colell's approach illustrates a feature of many transfer-pricing schemes that view transfer prices as the outcome of a game between the firm's affiliates; in the case of Shapley values, affiliates are awarded profits based on their threats to withdraw from the coalition that produces the final good. But such an approach ignores the fundamental control that central management asserts over a firm's affiliates: affiliates do not have the option of withholding their outputs from the rest of the firm.<sup>8</sup>

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<sup>8</sup>It is, of course, possible that agency problems within an integrated firm prevent central management from exerting the kind of unitary control over its affiliates assumed in this paper. Specifically, ambitious managers of foreign

There are at least four sources of inefficiency that can arise from the abilities of firms to choose the prices at which they record trades between their own affiliates. The transfer pricing literature focuses on the first: the problem that unless transfer prices of intermediate goods equal their marginal revenue products, firms have incentives to choose inefficient combinations of intermediate goods.

A second source of inefficiency is simply that the market produces too much output of those goods that are tax-favored due to firms' abilities to adjust the transfer prices of their intermediate goods.

The third inefficiency is that firms may undertake largely unproductive activities such as establishing affiliates in tax havens and moving some of their real activities to havens in order to facilitate transfer-pricing operations. The location of producing centers is a choice variable, so firms will attempt to locate their profitable operations in low-tax areas (and their unprofitable operations in high-tax areas).

The fourth inefficiency is somewhat subtler: firms may alter the nature of the products they sell in order to create situations in which large profits can be earned in low-tax locations. Suppose that a firm has two product lines, one very profitable and one that earns just a normal return. Then if

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affiliates may be compensated in a way that is a positive function of local profits and therefore would be reluctant to consent to cooperative transfer prices that maximize joint profits. There is not much evidence of the presence of agency costs of this type in practice. If such agency costs were important, then one way for central management to respond might be to require steady dividend payments from foreign subsidiaries in order to discipline the managers of those subsidiaries, as Jensen (1986) has argued in the purely domestic context. But the evidence (Hines and Hubbard, 1990) is that only a very small fraction of foreign subsidiaries repatriate earnings each year, suggesting that multinational financial policy is driven by tax minimization rather than agency considerations.

the tax authorities allocate total profits based on sales or employment,<sup>9</sup> it is in the firm's interest to *bundle* the two products, if it can, in a low-tax location. For example, a pharmaceutical manufacturer faced with a transfer-pricing regime that disallows firm-chosen transfer prices only when they create "excessive" returns in tax havens would find it in its interest to combine its very profitable pill manufacturing operations in Ireland with a costly operation that puts pills in boxes. By padding its Irish expenses in this way, the firm increases the fraction of its rents potentially assigned to its low-tax Irish affiliate, possibly raising its after-tax income even though the pills might be more efficiently boxed elsewhere (or for that matter, packaged in jars rather than boxes).<sup>10</sup>

### 3. A Profit Measure.

This section describes a new measure of affiliate profits, one that is simple in application and offers firms efficient incentives. In order to clarify some of the theoretical issues involved, assume that the government<sup>11</sup>

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<sup>9</sup>As is the case with formulas used to allocate corporate income for state taxation in the United States; this issue is further explored in section 4.

<sup>10</sup>Ireland offers most US manufacturing firms extended tax holidays. In 1981, Bausch & Lomb established a subsidiary in Ireland to manufacture contact lenses using a technique developed in New York; the Irish subsidiary paid a (small) royalty to the New York company for the right to manufacture this very profitable product. After litigation, a US Tax Court judge raised the royalty to permit the Irish company only a 27% annual pre-tax rate of return on investment. This is a very generous rate of return (particularly for a firm that enjoys a tax holiday) and an inducement to alter the production process to incur as many expenses as possible in Ireland. See Frisch and Horst (1989).

<sup>11</sup>In this paper "the government" refers to the governments of all interested countries. It is assumed that governments tax on the basis of mutually consistent transfer prices; hence, if German tax authorities determine the appropriate price of a good transferred from the US to Germany to be \$25, the American authorities would also tax the firm on the basis of a \$25 price. In practice, this kind of coordination is guaranteed by the provisions of most



at the end of the tax year has complete information about the production function used by the firm to produce revenue. Furthermore, assume that there is no ambiguity about the location of expenditures; the transfer pricing problem is the ex post assignment of revenues to different producing centers. Some of the issues that this framework ignores are considered in section 4.

The potential source of pure profit in this model is uncertainty concerning the production function, combined with the need to commit resources before uncertainty is resolved. Specifically, the affiliates of risk-neutral firms make product-specific expenditures on inputs, only to discover shortly thereafter the realization of a parameter that is crucial to the value of its output. Denote this parameter  $\phi$ ; its realization in state  $j$  is  $\phi_j$ . Firms know the distribution from which  $\phi_j$  is drawn, but the government does not; the government can observe only its realization. Denoting expenditures on input  $i$  in country  $j$  by  $X_{ij}$ , the overall (pre-tax) profits of the firm equal:

$$\Pi(X_{11}, \dots, X_{nm}; \phi_j; q_1, \dots, q_n) \quad (1)$$

in which there are  $n$  intermediate goods and  $m$  countries; the  $\Pi(\cdot)$  function is the reduced-form profit function that incorporates purchases of intermediate goods from sources outside the firm at prices  $q_1, \dots, q_n$  and that can be purchased by the firm after the state  $\phi_j$  is revealed. It is possible for the prices  $q_1, \dots, q_n$  (denoted  $q$ ) to be state-contingent. The notation in (1) suppresses the prices of the firm's outputs as arguments of the  $\Pi(\cdot)$  function; in general, those prices are functions of  $\phi$  and the actions of other firms.

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bilateral tax treaties.

It is equivalent to think of the output price to be normalized to unity (as in Lau, 1976).

The transfer pricing problem is the choice of a rule that divides  $\Pi$  in (1) among the  $m$  affiliates (one for each country) providing  $X_s$  to the firm. For simplicity of notation, assume that each affiliate purchases a distinct input, so that  $n = m$ ,  $X_{ij} = 0$  for  $i \neq j$ , and  $X_{ii}$  can be called  $X_i$ . Denote the vector of  $X_i$ s by  $\mathbf{X}$ .

In order to present a new solution to this problem, it is necessary to introduce the *restricted factor demand function*  $x_i[p, \mathbf{X}; \phi_j; q]$ . The vector  $p$  represents the prices of the  $n$  inputs. Unless otherwise specified, quantity units are initially chosen to normalize the prices in  $p$  to unity. The restricted demands represent the inputs chosen by a profit-maximizing firm facing no taxes and the problem:

$$\max_{\mathbf{x}} \Pi(\mathbf{x}; \phi_j; q) \quad (2)$$

subject to

$$x_i \leq X_i \quad \forall \quad i = 1, \dots, n \quad (3)$$

With these inputs the firm earns profits equal to  $\Pi(x_1[p, \mathbf{X}; \phi_j; q], \dots, x_n[\cdot]; \phi_j; q)$ ; this can be written in reduced form as the *restricted profit function*  $\pi[p; \mathbf{X}; \phi_j; q]$ . McFadden (1978) discusses the restricted profit function and its properties, including the derivative property: for a large class of production technologies and almost all commodity vectors,

$$-x_i[p, X; \phi_j; q] = \frac{\partial \pi[p; X; \phi_j; q]}{\partial p_i} \quad (4)$$

It can be shown (McFadden, 1978; see also Diewert, 1973) that as long as the set of possible production plans within the space bounded by  $0 \leq x_i \leq X_i \forall i=1, \dots, n$  is closed, nonempty and semi-bounded, then the derivative on the right side of (4) exists and is continuous in prices except possibly on a set of Lebesgue measure zero. Henceforth consideration is restricted to production processes admitting restricted profit functions with continuous first derivatives.

Consider the following method of profit allocation:

$$\pi_i(X; \phi_j; q) = \int_0^{\infty} x_i[\alpha, X; \phi_j; q] d\alpha = X_i \quad (5)$$

in which  $\pi_i(\cdot)$  is affiliate  $i$ 's allocated profit, the vector  $\alpha = (\alpha, \dots, \alpha)$  is a vector of  $n$  prices all equal to  $\alpha$  and the function  $x_i[\cdot]$  is the restricted factor demand function.

Figure one illustrates the  $\pi_i(\cdot)$  mechanism; the locus in the figure indicates the realization of a restricted demand schedule in a scenario characterized by ex ante uncertainty. The availability of a perfect substitute for  $x_i$  at price  $q^*$  drives demand to zero at that point, while in general the schedule need not slope downward in  $\alpha$ . In the absence of a liquid resale market unaffected by  $\phi$  there is no presumption that  $x_i = X_i$  at  $\alpha = 1$ . The shaded area equals  $\pi_i(X; \phi_j; q) + X_i$ .

*Feature 1: The mechanism (5) fully distributes revenues.*

*Proof:* Profits equal  $\Pi(\mathbf{X}; \phi_j; q)$ . With free disposal of inputs, this must equal  $(\pi[0; \mathbf{X}; \phi_j; q] - \sum_i X_i)$ , since at zero price the firm would use every input up to its limit  $X_i$ , unless the input becomes unproductive. Since firms facing infinite input prices and finite output prices earn zero profits,  $\pi[\infty; \mathbf{X}; \phi_j; q] = 0$ . Combining these,

$$\Pi(\mathbf{X}; \phi_j; q) = \pi[0; \mathbf{X}; \phi_j; q] - \pi[\infty; \mathbf{X}; \phi_j; q] - \sum_{i=1}^n X_i \quad (6)$$

Applying the fundamental theorem of the calculus to the right side of (6):

$$\Pi(\mathbf{X}; \phi_j; q) = \int_{\infty}^0 \frac{\partial \pi[\alpha; \mathbf{X}; \phi_j; q]}{\partial \alpha} d\alpha - \sum_{i=1}^n X_i \quad (7)$$

Then applying the chain rule and (4) to (7),

$$\Pi(\mathbf{X}; \phi_j; q) = \sum_{i=1}^n \int_0^{\infty} x_i[\alpha, \mathbf{X}; \phi_j; q] d\alpha - \sum_{i=1}^n X_i \quad (8)$$

which equals the sum over  $i$  of (5).

One of the critical features of the mechanism (5) is that its outcome is unaffected by the level of aggregation at which affiliates are defined. In order to make this concept more precise, consider two affiliates located in countries with identical tax systems (or two affiliates located in the same

country). Define two affiliates to be *bundled* if their costs and outputs are combined: if affiliates  $i$  and  $j$ , with respective expenditures  $X_i$  and  $X_j$ , are bundled together into a new affiliate, its expenditures equal  $X_i + X_j$ , and the inputs it uses to produce output is the vector sum  $X_i + X_j$ .

*Feature 2: The mechanism (5) attributes profits in a manner that is unaffected by the bundling of affiliates.*

*Proof:* There are two parts of the proof of this feature. The first part demonstrates that the mechanism (5) assigns to  $h$  affiliates, if bundled together, the same total profits it would if they were combined into one affiliate. The second part of the proof shows that such a bundling would not affect the assigned profits of any of the other, unbundled, affiliates.

Consider an affiliate that (on paper) combines the operations of affiliates  $1, \dots, h$ , and let the subscript  $\eta$  denote this newly formed affiliate. The output of the  $\eta$  affiliate is then the sum of the outputs of what were, previously, the first  $h$  affiliates; these outputs are now "bundled." Affiliate  $\eta$ 's attributed profits now equal:

$$\pi_\eta(\mathbf{X}; \phi_j; q) = \int_0^\infty x_\eta[\alpha, \mathbf{X}; \phi_j; q] d\alpha - X_\eta \quad (9)$$

But since  $x_\eta[\alpha, \mathbf{X}; \phi_j; q] = \sum_1 x_i[\alpha, \mathbf{X}; \phi_j; q]$ , and  $X_\eta = \sum_1 X_i$ , then (9) equals the sum of the assigned profits of the first  $h$  affiliates when unbundled and attributed separately.

To satisfy the second part of the proof, it is enough to observe that

$x_i[\alpha, \mathbf{X}; \phi_j; q]$  for  $i > h$  is unaffected by the bundling of the first  $h$  affiliate outputs, as long as the  $\mathbf{X}$  vector is unchanged by the bundling.

The first feature establishes that the mechanism (5) works, in the sense of allocating total firm profits among producing affiliates. The second feature establishes that, once production is complete (and the state of the world is revealed), the firm cannot somehow change its tax burden by rebundling the ownership of its affiliates. The next feature indicates an important case in which the mechanism provides efficient incentives for the initial allocation of resources to the  $X_i$ s.

*Feature 3: If the production technology provides efficient incentives for firms in a free-entry equilibrium in the absence of taxes, then when profits are allocated according to the mechanism (5), firms in a free-entry equilibrium face efficient incentives in the presence of taxes.*

*Proof:* Suppose not. Then there must exist a production plan  $\mathbf{X}'$  for which after-tax expected profits exceed those from the plan  $\mathbf{X}$  that would be adopted by competitive firms in the absence of taxes. Hence it must be the case that expected before-tax profits are positive for at least one  $i$  under the plan  $\mathbf{X}'$ . But since profits are unaffected by the bundling of outputs, it would be possible for a new firm to enter, produce only the good  $i$ , offer to sell the good to other firms (at a price that is an element of the  $q$  vector), and expect to make a before-tax profit. This single-good firm therefore also expects to make an after-tax profit, since all of its activities can take place in just one country. This violates the zero-profit condition of free

entry, so firms instead must adopt the plan  $X$ , under which, by the same argument, the production of each intermediate good has zero expected profit, and which is efficient by assumption.

Free entry and the ability to substitute between intermediate goods produced by the firm's own affiliates and those produced by other firms and purchased at prices  $q$  lie at the heart of Feature 3. In the absence of taxes, competition and potential entry force firms to choose efficient input combinations. The presence of taxes would normally encourage firms to incur costs in high-tax locations if some of the revenues thereby generated could be allocated to low-tax locations. But with the mechanism (5) and free entry it is impossible to undertake such a tax arbitrage, since the goal of the arbitrage is to create expected profits for some (low-tax) affiliates. Under free entry no affiliate can expect to earn profits, since if one could then there would be an incentive for additional entry.

*Example:* Suppose that each firm produces output with a state-contingent, constant-returns Leontief production function  $Q = \min[X_1\phi^1_j, \dots, X_n\phi^n_j]$  in which  $(\phi^1_j, \dots, \phi^n_j)$  are the same for every firm in state  $j$ . The economy's inverse demand function for output is  $p(Q)$ . Suppose that there is free entry and firms need not use intermediate goods produced by their own affiliates. It transpires, however, that in equilibrium firms make identical choices of  $(X_1, \dots, X_n)$  and never use the market for intermediate goods. In a Nash equilibrium with small firms each takes  $p$  to be a parametric function of  $\phi$ ,  $p(\phi)$ , and conditional factor demands take the form:

$$\begin{aligned}
 x_1[\alpha, \mathbf{X}; \phi_j; \infty] &= Q(\mathbf{X}, \phi_j)/\phi_j^1 & \text{if } p(\phi_j)/\alpha > \sum_i \phi_j^i \\
 &= 0 & \text{otherwise}
 \end{aligned}
 \tag{10}$$

in which  $Q(\mathbf{X}, \phi_j) = \min[X_1\phi_j^1, \dots, X_n\phi_j^n]$ . Figure 2 presents the conditional factor demand curves for goods  $x_1$  and  $x_2$  under a particular realization of  $\phi$  in which  $p(\phi_j)/[\sum_i \phi_j^i] - 1 = \delta > 0$ . As the figure indicates, affiliate 1 earns a profit of  $\delta$  on each unit of output up to  $Q/\phi_j^1$ , after which the affiliate receives nothing for its marginal output. The construction of  $Q(\cdot)$  ensures that  $X_1 \geq Q/\phi_j^1$ , so  $\pi_1(\mathbf{X}; \phi_j; \infty)$  takes the value  $\delta Q/\phi_j^1 - (X_1 - Q/\phi_j^1)$ . If expected profits of an affiliate were positive, then an entrant could profitably offer to sell its output at state-contingent prices; if all firms choose efficient  $\mathbf{X}$  profiles then no entry occurs.

This example offers a solution to the problem described in section 2, in which tax authorities must allocate the profits of a computer firm between its California and German affiliates. In this problem, the conceptual difficulty is that both affiliates produce intangibles that have no substitutes and are essential to the firm's profitability. The lesson of Example 1 is to allocate the firm's revenues to each affiliate in a manner that is proportional to costs, up to the point at which affiliate expenditures are necessary for the development of their respective intangibles. Note that the availability of a perfect substitute for an input would truncate its restricted demand curve at the price of the substitute. Hence those expenditures with ex ante certain returns must earn no more than normal economic returns, regardless of the profitability of the firm overall. In the example of the computer firm, its Singapore manufacturing affiliate would earn only normal returns if it is



established after the manufacturing intangible is developed in California and there is no residual uncertainty over its technology.

One explanation for this type of solution to the double-intangible problem concerns bundling: in the case of perfectly complementary inputs, cost is the only additive metric of affiliate input. If profits were allocated to inputs on any basis other than cost, then the profit allocation method would lose the feature of invariance with respect to bundling, and thereby would no longer provide efficient incentives. This solution has what at first might appear to be the troubling feature that greater cost earns an affiliate more profits rather than less. But since revenues are attributed on the basis of only those input expenditures that contribute to output, and efficiency requires each input to earn zero expected profit, then it is not surprising that in an efficient mechanism revenues are closely linked to costs.

There is a related explanation for the solution form (5), and its implication that revenues be assigned in a manner proportional to costs. Costs are deductible in countries where they are incurred,<sup>12</sup> and the benefits of those deductions are proportional to tax rates. In order not to have tax rate differences influence the allocation of resources, it must be the case that revenue allocations mimic cost distributions, so that in every country expected profits are zero.

The solution described by (5) is dual to the Aumann-Shapley (1974) solution as applied to this problem by Hart and Mas-Colell (1988, 1989). The Aumann-Shapley mechanism has also been widely used in the literature on

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<sup>12</sup>Though this is not always true of certain research and development expenditures by American multinationals. US tax law varies, but from time to time has required American firms to allocate some of their research and development costs against foreign income, thereby removing (some of) its deductibility against domestic US income.

allocation of fixed costs, as in Samet and Tauman (1982), Mirman, Samet and Tauman (1983), and Young (1985). Hart and Mas-Colell require that their solution be standard for two-person games, thereby imposing that their solution not satisfy the bundling condition when the firm can choose the number of its own producing centers. The cost-allocation literature imposes consistency conditions that resemble the bundling condition, but by steadfastly refusing to incorporate demand conditions is unable to offer solutions that distinguish profitable from unprofitable operations.

The efficiency result of Feature 3 relies on the potential competition of new entrants to discipline the actions of producing firms. In some cases of interest, however, producing firms do not appear to be able to purchase certain of their intermediate goods from outside companies. One can think, for example, of cases in which intermediate goods vary in quality, verification is costly, and one-time interaction between sellers and buyers combined with opportunism makes arm's-length transactions of intermediate goods much more costly than vertical integration. In such cases firms may have expanded opportunities to manipulate the tax system by strategically choosing to underinvest in some inputs and overinvest in others. In order to isolate some cases in which such opportunities do not arise, it is useful to introduce the property (CC) (constraint continuity):

*Definition 1:* The production function exhibits constraint continuity (CC) if, for every realization  $\phi_j$  of  $\phi$  and choice of the smallest possible  $\alpha'$  such that  $x_i[\alpha', \mathbf{X}; \phi_j; q] < X_i$  for some (possibly more than one)  $i \in [1, \dots, n]$  and  $x_k[\alpha', \mathbf{X}; \phi_j; q] = X_k \forall k \neq i$ , there does not exist  $\alpha'' > \alpha'$  such that  $x_i[\alpha'', \mathbf{X}; \phi_j; q] = X_i$ .

*Definition 2:* The production function is regular (R) if the production possibility set is closed, nonempty, semi-bounded, and strongly continuous.

*Discussion:* Figure 3 offers an illustration of a case that violates condition (CC). In order to violate the condition, it must be the case that the conditional demand curve for  $x_1$  bends backward sufficiently to make the  $x_1 \leq X_1$  constraint bind at prices above  $\alpha^*$ ; this cannot arise unless some other input is a strong substitute for input 1. McFadden (1978) demonstrates that the regularity conditions (R) imply that the Hessian matrix of the profit function is symmetric non-negative definite. Imposing (4) and the condition that  $d\alpha_1 = d\alpha_j \forall i, j$  along the path of integration in (5), it must therefore be the case that for production functions satisfying (R),

$\sum_i \partial x_i[\alpha, X; \phi_j; q_j] / \partial \alpha < 0$ : the demand curve for aggregate inputs is downward sloping. The case pictured in figure 3 requires not only that the demand curve for input 1 be backward bending, but sufficiently backward bending to reach the constraining quantity; on prior grounds it is unlikely.

*Feature 4:* Suppose that the production technology satisfies properties (CC) and (R), and yields an efficient allocation of resources in a free-entry equilibrium in the absence of taxes. If firms cannot purchase quantities of  $X$  from each other after the realization of  $\phi$  (elements of  $q$  for goods  $1, \dots, n$  are infinite), but their revenue functions are differentiable and weakly separable in  $(X, q)$  and  $\phi$ , then resources will be allocated efficiently in a free-entry equilibrium in the presence of taxes.

*Proof:* Suppose, for simplicity, that each of the  $z$  states of the world were

equally likely. Then the firm's optimization problem is:

$$\max_{\mathbf{X}} (1/z) \sum_{j=1}^z \sum_{i=1}^n (1 - \tau_i) \int_0^{\infty} x_i[\alpha, \mathbf{X}; \phi_j; q] d\alpha - (1 - \tau_i)X_i \quad (11)$$

in which  $\tau_i$  is the profit tax rate in affiliate  $i$ 's jurisdiction. Note that the same maximization, with all the  $\tau_i$ s equal to zero, corresponds to the first-best allocation of  $X_i$ s. In order to evaluate (11) it is necessary to determine the restricted factor demand schedules.

If revenue functions are weakly separable in  $(\mathbf{X}, q)$  and  $\phi$ , then  $R[\mathbf{X}, \phi, q] = \theta[\psi(\mathbf{X}, q), \phi] \forall (\mathbf{X}, \phi, q)$ . Differentiability of  $R$  and the firm's first-order condition imply that if  $0 < x_i[\alpha, \mathbf{X}; \phi; q] < X_i$  then  $\alpha = \partial R / \partial X_i = (\partial \theta / \partial \psi)(\partial \psi / \partial x_i)$ , as long as the arguments of both the  $\theta$  and  $\psi$  functions are the restricted demands  $\mathbf{x}[\alpha, \mathbf{X}; \phi; q]$ . If  $x_i = X_i$  then  $\alpha \leq (\partial \theta / \partial \psi)(\partial \psi / \partial x_i)$ ; and if  $x_i = 0$  then either  $\alpha > (\partial \theta / \partial \psi)(\partial \psi / \partial x_i)$  or there are no profitmaking configurations at  $(\alpha, \mathbf{X}, \phi_j, q)$ .

Suppose that the firm maximizes after-tax profits and that for some realization  $\phi_j$ ,  $0 < x_i[\alpha^*, \mathbf{X}; \phi_j; q] < X_i$  and  $x_k[\alpha^*, \mathbf{X}; \phi_j; q] = X_k \forall k \neq i$  over the range  $\alpha^* \in [\alpha_1^j, \alpha_3^j]$ . Then for a different realization  $\phi_h$  there must exist a similar range  $\alpha^{**} \in [\alpha_1^h, \alpha_3^h]$  such that  $0 < x_i[\alpha^{**}, \mathbf{X}; \phi_h; q] < X_i$  and  $x_k[\alpha^{**}, \mathbf{X}; \phi_h; q] = X_k \forall k \neq i$ : set  $\alpha^{**} = \alpha^*(\partial \theta[\psi, \phi_h] / \partial \psi) / (\partial \theta[\psi, \phi_j] / \partial \psi)$ . The regularity conditions guarantee the existence of such an  $\alpha^{**}$  as long as  $x_i[0, \mathbf{X}; \phi_h; q] \geq X_i$ , since  $x_i[\infty, \mathbf{X}; \phi_h; q] = 0$  and McFadden (1978) shows that (R) implies that restricted factor demands are continuous in prices (and exhibit no 'flats' along which  $\partial \theta / \partial x = 0$ ). While the following argument presumes that all inputs are demanded at zero price for all realizations of  $\phi$ ,

it is unchanged by including  $\phi_s$  for which inputs are unproductive.

Thus the firm's expected profits equal:

$$\begin{aligned}
 E(\Pi) = & (1/z) \sum_{j=1}^z \sum_{k \neq i}^n (1 - \tau_k) \left( \int_{\alpha_3^j}^{\infty} x_k[\alpha, \mathbf{X}; \phi_j; q] d\alpha - X_k(1 - \alpha_3^j) \right) \\
 & + (1/z) \sum_{j=1}^z (1 - \tau_1) \left( \int_{\alpha_1^j}^{\infty} x_1[\alpha, \mathbf{X}; \phi_j; q] d\alpha - X_1(1 - \alpha_1^j) \right) \quad (12)
 \end{aligned}$$

Consider, then, an alternate production plan  $\mathbf{X}'$  in which  $X'_k = X_k \forall k \neq i$  but the firm selects  $X'_1 < X_1$  such that  $x_1[\alpha, \mathbf{X}'; \phi_j; q] = X'_1$  for  $\alpha \in [\alpha_1^j, \alpha_2^j]$ ,  $\alpha_2^j \leq \alpha_3^j$ . By the property (CC), it must be the case that  $x_k[\alpha, \mathbf{X}'; \phi_j; q] = x_k[\alpha, \mathbf{X}; \phi_j; q] \forall k \neq i$ . Furthermore, downward sloping aggregate demand guarantees that  $x_1[\alpha, \mathbf{X}'; \phi_j; q] = x_1[\alpha, \mathbf{X}; \phi_j; q]$  for  $\alpha \in [\alpha_2^j, \infty]$ . Denoting by  $\Delta\Pi$  the change in after-tax profits introduced by substituting  $\mathbf{X}'$  for  $\mathbf{X}$ ,

$$\Delta\Pi = (1/z) \sum_{j=1}^z (1 - \tau_1) (X_1(1 - \alpha_1^j) - X'_1(1 - \alpha_2^j) - \int_{\alpha_1^j}^{\alpha_2^j} x_1[\alpha, \mathbf{X}; \phi_j; q] d\alpha) \quad (13)$$

Since  $x_1[\alpha, \mathbf{X}; \phi_j; q] \leq X_1$ , the integral in (13) is bounded above by  $X_1(\alpha_2^j - \alpha_1^j)$ , and:

$$\Delta\Pi \geq (1/z) \sum_{j=1}^z (1 - \tau_1) (X_1 - X'_1)(1 - \alpha_2^j) \quad (14)$$

In order for the plan  $\mathbf{X}$  to represent an optimal choice, it is necessary that

$\Delta\pi \leq 0$ . From (14), a necessary condition is that

$$(1/z)(1 - r_1)(X_1 - X'_1)\Sigma_j(1 - \alpha_2^j) \leq 0. \quad \text{Since } X_1 > X'_1, \text{ this condition implies} \\ (1/z)\Sigma_j\alpha_2^j \geq 1.$$

Hence a necessary condition for a small reduction in input  $i$  not to raise expected profits is that the expected value of  $\alpha$  at which its quantity constraint bind not be below unity. But if  $(1/z)\Sigma_j\alpha_2^j > 1$  then by setting  $\alpha_2^j = \alpha_3^j$  in (12) it must be the case that every affiliate in the firm earns profits in expectation. So it is not possible for there to be a single affiliate  $i$  for which  $x_i[\alpha, X; \phi_j; q] < X_i$  while  $x_k[\alpha, X; \phi_j; q] = X_k, \forall k \neq i$ . By feature 2, this argument is unchanged if  $x_i$  is replaced by a bundle of several affiliates. Therefore at the optimum  $(1/z)\Sigma_j\alpha_2^j = 1$  for every affiliate, and resources are allocated efficiently in the sense that no reallocations are possible that would have raised expected profits in the absence of taxes.

Figure 4 illustrates the proof of Feature 4. The restricted factor demand schedules are pictured for a particular realization of  $\phi$ ; assume that this represents the *only* possible realization of  $\phi$ . Since variations in  $X_1$  between  $X^1$  and  $X^3$  affect only the return attributed to affiliate  $i$ , it is clear that ex ante the firm chooses  $X_i = X^2$ , at which  $\alpha = 1$ . Notice, however, that as pictured affiliates  $i$  and  $j$  both earn profits from this configuration, since (from (5)) their returns over the interval  $\alpha = 0$  to  $\alpha = 1$  equal  $X_i$  and  $X_j$  respectively, and may exceed it elsewhere. In a zero-profit equilibrium it must be the case that expected profits for each affiliate equal zero, so each must be at the margin when  $\alpha = 1$ . But this is exactly the efficiency condition, so the mechanism (5) supports an efficient outcome.

There are cases in which the mechanism (5) does not support an efficient allocation of resources in the presence of differentiated tax rates. The reason it does not do so has, ultimately, to do with the government's limited information. With certain production technologies and limited ability to buy intermediate goods on the market, a mechanism such as (5) may give firms incentives to overspend on intermediate goods produced in high-tax locations and underspend on those produced in low-tax locations, if the two goods are complementary in production. The reason that this strategy can be profitable is that the firm is able to create something of an artificial shortage of the lightly-taxed intermediate good, thereby raising its value and the revenue assigned to a low-tax jurisdiction. The outcome of this tax arbitrage is not only to distort input proportions, but also to produce too much of the final product relative to the efficient quantity. The following feature illustrates the informational nature of the government's limitations.

*Feature 5: Suppose that the production technology yields an efficient allocation of resources in a free-entry equilibrium in the absence of taxes, and that the government has complete information about the distribution of  $\phi$  from which  $\phi_i$  is drawn. Then even if firm-produced intermediate goods cannot be traded, the government can support an efficient outcome in the presence of taxes by using a mechanism related to (5).*

*Proof:* Define the ex ante demand for expenditure by affiliate  $i$  in a tax-free world to be  $x_i[\alpha, \infty; \Phi; q]$ , in which the  $\infty$  argument indicates that all input quantities are initially unconstrained, while the  $\Phi$  argument indicates that the demand for  $x_i$  is conditional on the entire distribution of  $\phi$ , not just one

realization of it. Let  $I_i$  represent the vector with every element but the  $i$ th equal to  $\infty$ , and the  $i$ th equal to  $X_i$ :  $I_i = (\infty, \dots, \infty, X_i, \infty, \dots, \infty)$ . Define the expected profit of affiliate  $i$ ,  $\Omega_i(\mathbf{X}; \Phi; q)$ , to be:

$$\Omega_i(\mathbf{X}; \Phi; q) = \int_0^{\infty} x_i[\alpha, I_i; \Phi; q] d\alpha - X_i \quad (15)$$

Then consider the profit assignment mechanism  $\pi_i(\mathbf{X}; \phi_j; q) = \Pi(\mathbf{X}; \phi_j; q)\sigma_i$ , in which  $\sigma_i = \Omega_i(\cdot) / \sum_j \Omega_j(\cdot)$ , unless  $\sum_j \Omega_j(\cdot) = 0$ , in which case  $\sigma_i = X_i / \sum_j X_j$ .

This mechanism clearly exhausts profits; that it also induces efficient behavior is implied by the properties of (15). It must be the case that  $\Omega_i(\cdot) \leq 0 \forall i$ , since  $x_i[\alpha, I_i; \Phi; q] = 0 \forall \alpha > 1$ ; if not, then firms could enter and make expected after-tax profits. If all affiliates make efficient expenditures, so that  $\Omega_i(\cdot) = 0 \forall i$ , then profits (zero in expectation) are allocated among affiliates according to costs. If, on the other hand, some affiliates make inefficient expenditures ( $\Omega_i < 0$ ), those affiliates are assigned the firm's profits, which are negative in expectation. Every firm would prefer the efficient alternative with zero expected profits.

The problem with implementing such a system is that it is difficult to make tax rules that rely on knowing the distribution of individuals' beliefs at times in the past; it is bad enough to require knowledge about current production processes. To a certain extent the tax system must rely on contemporaneous past expectations, such as in assessing the riskiness of an investment when it was made, but it is usually unrealistic to demand too much of such information on the part of the government. Furthermore, full-



information systems (including the mechanism based on (15)) often do not yield solutions that are unaffected by the bundling of affiliates, a feature that makes them particularly sensitive to the requirement that the government's information be complete. Fortunately, Features 2-4 indicate that the mechanism (5) has a number of attractive properties even in the absence of such comprehensive government information.

#### 4. Implications.

Section 3 analyzes the transfer pricing problem under rather stylized conditions that are not always encountered in practice. In particular, the analysis presumes that the government has access to all the needed information about relevant demand and cost functions. This information is of course not always available - indeed, firms may not themselves know their own costs or the derived demands for the output of their own affiliates. When they do, firms might often have incentives to mislead the government. Naturally, this problem is not limited to the domain of transfer pricing: if firms could report losses rather than profits then they would never pay taxes.

There are three alternative approaches to the problem of limited information. The first is to implement a chosen transfer-price rule using an incentive-compatible information revelation scheme, if the rule admits one.<sup>13</sup> The second is to use whatever information the government may have without firm

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<sup>13</sup>Donnenfeld and Prusa (1989) explore some of the tradeoffs inherent in choosing an implementable rule, and argue for the desirability of quantity as well as price instruments in the implementation scheme. There remains, of course, the issue of designing rules that offer firms efficient incentives. Donnenfeld and Prusa derive the efficient rule for a single government that seeks to extract as much of the firm's surplus as possible, taking the surplus to be fixed. The results in this paper suggests that it is a mistake to ignore the sources of firms' profits, while the analysis is premised on the notion that governments coordinate their assessments of taxable income.

reporting to characterize transfer prices in at least certain situations. And the third alternative is to abandon altogether the attempt to determine the location of income, and allocate the tax base instead on the basis of simple formulas.

The third alternative is the one chosen by American states in allocating corporate income for purposes of the state income tax. Forty-five states tax corporate income, often at different rates. States employ formulas to determine local taxable incomes when corporations have activities outside the taxing state and their operations are deemed to be "unitary", which means that some degree of complementarity exists between the outputs or operations of in-state and out-of-state affiliates.<sup>14</sup> Formulas differ, but a commonly-used scheme divides domestic profits of unitary corporations among states based evenly on the fraction of a firm's total domestic payroll, sales, and property located within each state.<sup>15</sup> These formulas offer the advantage of administrative simplicity, but are typically quite distortionary, as Gordon and Wilson (1986) demonstrate.<sup>16</sup>

The first two approaches are undoubtedly difficult to implement. The analysis in section 3 suggests, however, that in the case of a firm earning

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<sup>14</sup>McLure (1984) and Musgrave (1984) evaluate the attributes that properly characterize a "unitary" business. One interpretation of the mechanism (5) in this paper is that it formalizes the concept of a "unitary" corporation in a way that simultaneously allocates profits among affiliates.

<sup>15</sup>This is the so-called "Massachusetts formula" (though it is not used by Massachusetts). Some states such as California and Oregon use formulas that allocate a corporation's worldwide income based on the fraction of its worldwide activity located within their states; see Carlson and Galper (1984).

<sup>16</sup>Nonetheless, there are a number of serious proposals to introduce an American-style formula apportionment scheme for direct corporate taxation in the European Community; see McLure (1989) and Weiner (1990). For an alternative that removes the need to determine the location of corporate earnings, see Giovannini and Hines (1990).

rents from multiple intangibles, governments can support efficient outcomes by allocating total firm profits to each location based on its share of expenditures on developing intangibles. Such a rule would generally be simple to administer - indeed, simpler than some rules currently in force. Of course, its administration would require the firm to identify costs rather precisely.<sup>17</sup> Furthermore, the government would need to be certain that the intangibles were developed simultaneously, and not in sequence.

Without strong enforcement efforts firms will always be able to evade some taxes with illegal bookkeeping. But short of that many apparently manipulated prices are currently - or at least arguably - legal. This problem arises in part because there is no consistent conceptual framework on which tax authorities can base their transfer pricing rules. In response governments typically permit firms to choose among procedures that divide profits between their operations, with predictable results. In recognition of this problem the US Department of the Treasury recently (1988) issued a White Paper outlining substantial proposed changes in transfer pricing regulations. But even the White Paper proposals offer firms considerable latitude.

The mechanism presented in this paper suggests that the arm's-length standard, if applied according to (5), supports an efficient allocation of

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<sup>17</sup>One practical difficulty with such a scheme is that in certain circumstances profitable firms might have incentives to incur extra costs in some low-tax locations in order to increase the fraction of firm profits that is lightly taxed. Specifically, suppose that after realization of  $\phi$  a firm has total revenue of  $R$ , produced by  $n$  complementary inputs with cost  $c_i \forall i=1, \dots, n$ . Using (5), after-tax profits for the firm are  $\sum_i (1-r_i)c_i[R/C - 1]$ , in which  $C = \sum_i c_i$ . Suppose the firm could incur an additional cost of  $\$1$  in location  $i$ , and do so in a way that includes the cost in the allocation of firm revenues. The change in after-tax firm revenues would be  $(1-r_i)[R/C - 1] - (R/C^2)\sum_j (1-r_j)c_j$ . This change can be profitable only in those cases in which the firm's profit rate exceeds the reciprocal of its weighted-average tax rate, with weights determined by shares in total costs. To see this, consider the most favorable case in which  $r_i = 0$ ; then the preceding equation is positive only when  $(R/C) \sum_j r_j(c_j/C) > 1$ .

resources in the presence of taxes. Note that such an application would assign rents in the double-intangible problem to affiliates based on costs, but not assign anything more than economic return to those affiliates that do not participate in the risks that generate those rents.

It almost goes without saying that such a solution is not sufficient for policy purposes. Efficiency is only one goal of the tax system. Furthermore, in the international context there are important issues (raised, for example, in Musgrave, 1972) concerning the equitable division of tax revenues between countries. The mechanism (5) described here represents an example of what Musgrave characterized as the "activity" approach to international tax base division. It offers the advantage not only of encouraging efficient behavior, but the (possibly) equitable feature of reflecting only the income-producing activities in a country, independent of their packaging and bundling. At the very least, it would appear to be a useful benchmark by which to measure the rules already in place.

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Figure 1

Restricted Factor Demand and Affiliate Revenue

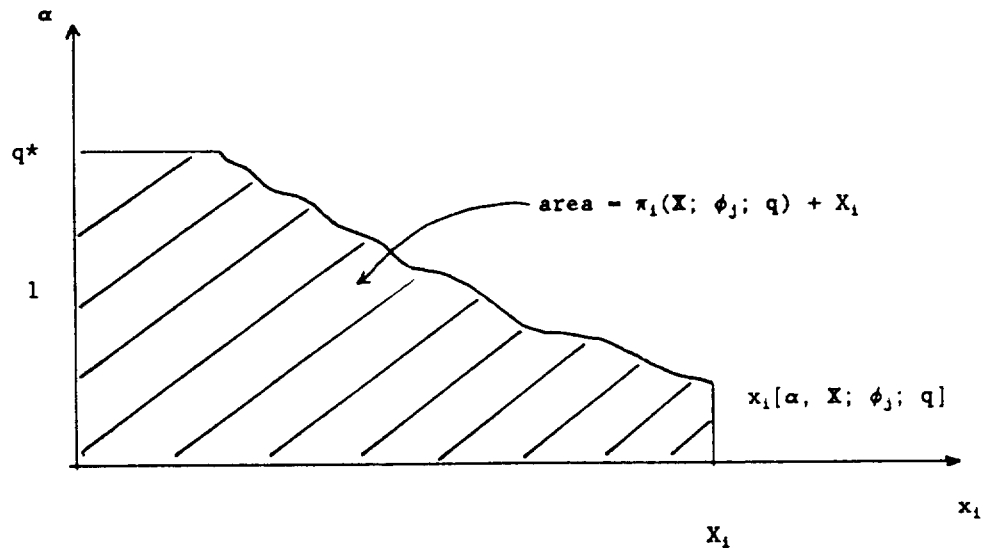


Figure 2

Restricted Factor Demands from a Leontief Production Function

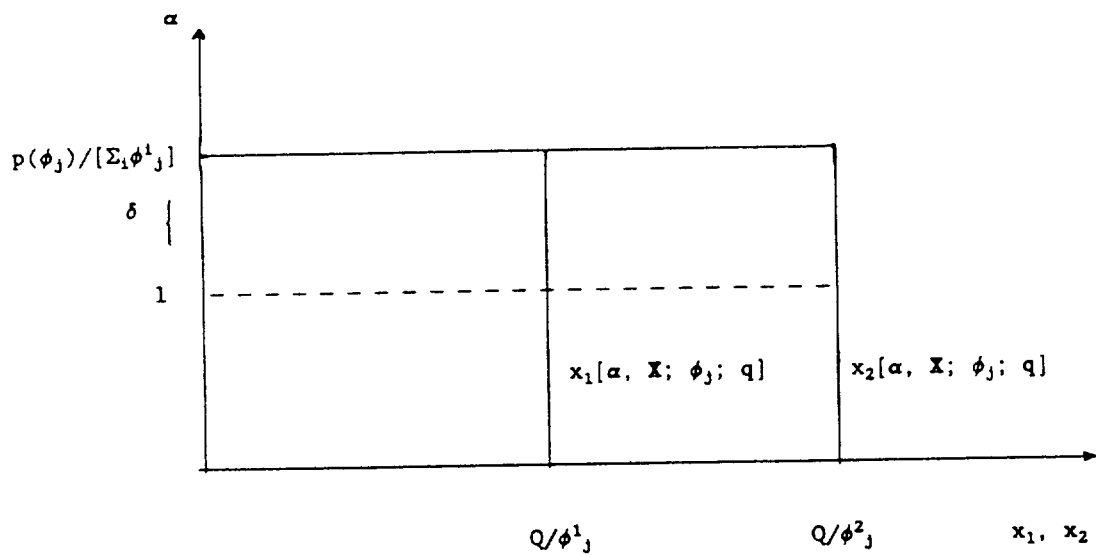


Figure 3

Violation of Condition (CC)

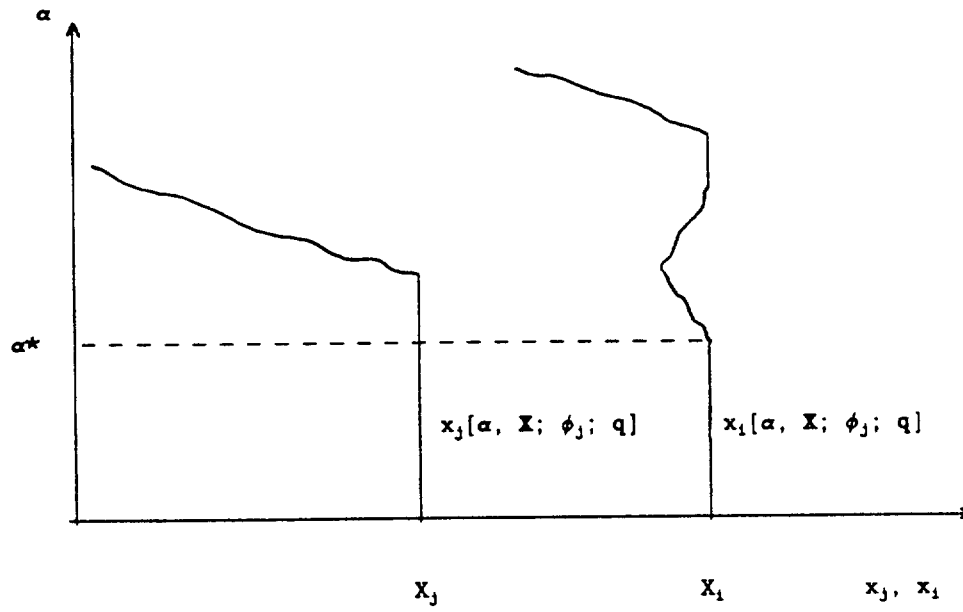


Figure 4

Choice of Affiliate 1 Expenditures By a Profitable Firm

