Incentive compatible regulation of a foreign-owned subsidiary

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Transfer prices are administered charges for intra-firm transfers of factors of production. For a multinational firm, transfer prices for international transfers provide the means to redistribute costs and increase global profits given variations in national tax and profit repatriation policies. Local regulation of a subsidiary may thus be necessary to limit the welfare costs of strategic transfer pricing. Prusa (Journal of International Economics, 1990, 28, 155-172) characterizes the welfare-maximizing regulations for a monopoly subsidiary that induce the firm to report transfer prices truthfully. We show, however, that it can be more efficient to implement regulations that encourage the firm to misrepresent its true transfer costs.

Key words: Transfer prices; Multinational regulation; Incentive compatibility

JEL classification: F13; F23; D82 C72

1. Introduction

Transfer prices are administered charges for intra-firm transfers of goods and factors of production. By misrepresenting the cost of a transfer, a firm can shift the apparent location of profits across national boundaries. For multinational enterprises (MNEs), transfer prices represent one of the more effective tools for dealing with disparate national tax and repatriation policies. The fact that MNEs can circumvent national tax and regulatory policies through the strategic use of transfer prices may explain, in part, why

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1See Lall (1973) for an extensive discussion of the incentives to engage in strategic transfer pricing. Benvennati (1985) presents a useful empirical study of the transfer-pricing behavior of U.S. firms.

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MNEs tend to be larger and more profitable than the average firm in the relevant industry. This same fact also provides an explanation for the interest on the part of national governments, especially those with protectionist interests, to regulate the transfer pricing of MNEs whose local subsidiaries represent foreign direct investment. One might therefore assume that national welfare is best served by implementing regulations that induce MNEs to report transfer prices truthfully. We will show that national welfare may in fact be best served by regulations that allow the firm to earn positive or negative transfer price profits.

Given the prominence of foreign direct investment and the significance of transfer pricing, it is not surprising that there is a substantial and sophisticated literature studying the phenomenon. Starting with the foundational papers by Copithorne (1971) and Horst (1971), a number of scholars have studied the effect of various tax/tariff regimes on the pricing and production decisions of MNEs and, conversely, the optimal regimes for regulating the profit-maximizing MNE. Until recently, however, the literature on the regulation of MNEs assumed that the national tax/regulatory authority possessed the information necessary to implement its optimal tax policy [Horst (1977, 1980), Diewert (1985), Hartman (1985)]. Thus, Prusa's (1990) recent extension of Baron and Myerson's (1982) model of optimal regulation of a domestic monopolist under incomplete cost information to the case of a multinational monopolist constitutes a considerable advance on the previous literature.

Because national regulations can create incentives to strategically misrepresent the cost of intra-firm transfers, a sophisticated government should adopt regulatory objectives that are incentive compatible with respect to the MNE's transfer pricing behavior. Following the literature on regulating a domestic monopolist, Prusa focuses attention on direct two-part regulatory schemes — that is, schemes in which the regulator sets a price and a lump-sum subsidy given the MNE's report of its marginal cost (in this case,
marginal cost is determined by the cost of a transferred intermediate good from one division of the MNE to a subsidiary operating in another country. The MNE's report is also assumed to be the transfer price charged to the division receiving the transfer. Regulating the subsidiary then is treated as a principal-agent problem in which the national regulatory/tax authority is the principal and the MNE is the agent possessing private information about the cost of production. As is usual in the literature that has grown out of Baron and Myerson's work, the national authority uses a subsidy to induce compliance with a second-best pricing/output scheme, where the second-best nature of the solution flows from the fact that the MNE must receive private information rents.

Prusa's analysis of the transfer price regulation problem is incomplete, however, because he restricts attention to regulatory schemes that induce the MNE to truthfully report the cost of its intermediate good. In many models, such a restriction involves no loss of generality because of the Revelation Principle. In the model Prusa analyzes, this is not necessarily true. A problem arises because the MNE's transfer price in Prusa's model serves two purposes. It redistributes the MNE's costs between its subsidiary and the parent firm and it communicates cost information to national authorities. If an MNE's transfer prices only played an informational role, inducing truthful cost reporting would not by itself create an additional welfare cost. But because transfer prices allow an MNE to increase its global post-tax profits via cost redistribution, they also have the potential to limit the national authority's ability to adequately control the MNE's global profits. Any attempt to induce truthful transfer prices may generate additional welfare costs by restricting how the national authority allows the MNE to earn its information rents. Therefore any analysis of optimal regulations must either disentangle the two tasks currently served by transfer prices or it must provide a proper accounting of the welfare costs associated with limiting transfer price distortions.

Disentangling the two roles played by transfer prices represents an application of Myerson's (1982) 'generalized Revelation Principle'. Although Myerson was concerned with moral hazard issues, of which none exists in this paper, his basic idea of expanding the set of available regulatory instruments still applies. In our paper, this involves the MNE reporting its transfer cost to the government. The government then uses the report to set the level of regulation and the MNE's transfer price. By setting the transfer price, the national authority gains control of both relevant dimensions of the MNE's profit: monopoly distortion and cost distribution. We refer to this option as direct transfer price regulation. Added flexibility in analyzing

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For the foundational work on the Revelation Principle, see Dasgupta et al. (1979), Myerson (1979), Rosenthal (1979), and Harris and Townsend (1981).
optimal regulations occurs because the transfer price need not equal the MNE’s reported costs. In fact, the two will generally not be equal under the optimal regulations.

If explicitly setting the MNE’s transfer price is not feasible for institutional or political reasons, then we are back to Prusa’s model. To properly account for a transfer price’s effect on national welfare, we use a technique first developed by Mirrlees (1971) by which identifying optimal regulations involves defining a set of performance targets – desirable price, repatriation, and subsidy levels – and then constructing a set of regulations that implement the performance targets. We refer to this option as indirect transfer price regulation because the government indirectly sets the MNE’s transfer price via the incentives created by its choice of regulations. If the optimal direct regulations include a strictly monotonic transfer-price rule, the optimal indirect regulations are payoff equivalent with the optimal direct regulations. If the optimal direct transfer-price rule is not strictly monotonic, the government strictly prefers direct regulation to indirect regulation.

The optimal regulations include features common in the regulation literature such as marginal cost plus pricing that reflects the second-best nature of the regulations and the fact that the MNE collects information rents. Features specific to the multinational case depend on the relative weights given consumer and producer surplus by the national regulator. When the value placed on producer surplus relative to consumer surplus is small (in a sense to be made precise below), the optimal regulations generally require zero operating profits for the local subsidiary and positive transfer-price profits. This case also supports a continuum of ‘knife-edge’ regulations that are optimal, including Prusa’s regulations that require truthful cost reporting. On the other hand, when the relative value of producer surplus is high, the optimal regulations require positive operating profits. Transfer-price profits can be either positive or negative and honest transfer pricing is never optimal.

The economic intuition for these results is straightforward. Although the government’s price regulation determines the level of information rents an MNE can earn, the MNE can collect these rents either as transfer-price profits or as operating profits from its subsidiary. This means that the government’s problem is to decide how best to distribute the MNE’s rents between these two sources. If the government restricts attention to regulations that induce truthful transfer prices, all of the MNE’s rents must take the form of operating profits. As we have suggested above, national welfare

7It is important to note that by invoking the Revelation Principle, the optimality of any resultant solutions can only be asserted and not proven unless the antecedents of the Revelation Principle are satisfied. In Prusa’s model they are not. Moreover, we will show that Prusa’s solution is optimal under certain economic conditions only if several modifications to his model are adopted.
can be enhanced by allowing the MNE to earn non-zero transfer-price profits.\(^8\)

Finally, we show that if the government requires the MNE's transfer price to fall within a prespecified interval, then with a minor modification of our model, there exist economic conditions under which the limit transfer pricing policies found in Copithorne (1971) and Horst (1971) are optimal direct regulations. It is not known whether limit transfer pricing is supported by optimal indirect regulations.

We begin our analysis in section 2 where we present Prusa's model of an MNE, describe the set of incentive compatible regulations that he claims maximize expected welfare for the country playing host to the subsidiary, and point out where his analysis is incomplete. In section 3 we characterize optimal direct regulations and in section 4 we characterize optimal indirect regulations. We conclude our discussion with some remarks in section 5.

2. A simple model of an MNE

We begin by presenting Prusa's model of an MNE which has its origin in the papers of Copithorne (1971) and Horst (1971).\(^9\) This model will provide a reference point for our arguments.

Consider the case of a parent company located in its Home country that owns and operates a subsidiary in a Host country. The parent company produces an intermediate product at Home and ships it to the subsidiary at a total constant marginal cost, \(\theta\). The subsidiary then transforms the imported intermediate good under fixed costs, \(k\).\(^10\) While the subsidiary's fixed cost is known to the Host government and the MNE or firm, only the MNE knows its marginal cost. The Host government believes that the firm's marginal cost is distributed according to \(G(\theta)\) with continuous positive density \(g(\theta)\) on the interval \([\theta_0, \theta_1]\). Finally, there is assumed to be some sort

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\(^8\)Two related studies of transfer pricing by an MNE are Raff (1991) and Stoughton and Talmor (1991). Raff derives the optimal transfer-price regulations when the MNE is involved in exporting intermediate goods to the parent firm. The focus on export transfer prices instead of import transfer prices allows him to avoid the complications associated with the Revelation Principle that we encounter. Stoughton and Talmor focus on the internal transfer-price policies of an MNE when the subsidiary has better information about its operations than does the parent. Their study then differs from ours in that our focus is on the problems of regulating an MNE when the informational asymmetry is between the MNE and the foreign government.

\(^9\)While the Horst and Copithorne models are formally equivalent, Horst analyzes transfer pricing in a horizontally integrated firm while Copithorne analyzes transfer pricing in a vertically integrated firm. Thus, our study more closely parallels that of Copithorne's. For numerous other examples in which the Horst and Copithorne models have been used, see Eden (1985).

\(^10\)This assumption, that the marginal cost of production in the affiliate is entirely due to the cost of the imported intermediate good, is fairly standard.
of exogenously determined interest differential between the two countries, \(i \geq 0\), so that the parent company weakly prefers to repatriate the subsidiary’s profits.\(^{11}\)

The subsidiary is a monopolist in the Host country facing a strictly decreasing inverse demand curve, \(P(\cdot)\). Moreover, we assume that market demand is large enough so that an unregulated subsidiary could earn positive economic profits regardless of its true costs. The Host government wishes to regulate the subsidiary’s operations through control of the market price, \(p\), a profit repatriation limit, \(\beta\), and a production subsidy, \(S\). Actually, we assume the regulator sets a market price indirectly by setting an output level, \(q\). Clearly, \(p = P(q)\). In addition, the subsidiary faces a corporate profit tax, \(\gamma \in [0, 1]\), and an ad valorem tariff, \(t\), on the imported intermediate product that are outside the control of the regulator.\(^{12}\)

Generally speaking the regulatory scheme the Host government uses will present the parent company with an incentive to distort the price it charges its subsidiary for the intermediate product. In so doing it can repatriate foreign earned profits in a manner not subject to the Host country’s regulations. The subsidiary earns operating profits of

\[ \pi(\theta_h) = P(q(\theta_h))q(\theta_h) - (1 + i)\theta_h q(\theta_h) - k + S(\theta_h) \]  

(1)

and pays Host taxes equal to \(\gamma \pi(\theta_h)\) when it reports a marginal cost of \(\theta_h\) to the Host government and faces the regulatory scheme, \((q(\theta_h), \beta(\theta_h), S(\theta_h))\). Thus, given the interest differential, the MNE’s global post-tax profit from its foreign operations (measured in the Host country’s currency) is

\[ \tau(\theta_h, \theta) = (1 + i)(\theta_h - \theta)q(\theta_h) + (1 - \gamma)(1 + \beta(\theta)(i)\pi(\theta_h)). \]  

(2)

We assume that knowing \(\theta\) and faced with the regulations \(Q=(q, \beta, S; t, \gamma)\) abroad, the firm chooses \(\theta_h\) to maximize (2). Let \(\theta^*_h(\theta)\) denote the firm’s optimal transfer-price strategy. In general it will be easier to define a regulatory scheme as a quantity schedule, a repatriation rate, and an

\(^{11}\)Prusa argues that the interest differential can be given a broad interpretation, incorporating such factors as exchange risk and political risk. While Prusa’s assumption that \(i > 0\) is perfectly reasonable, it may also be the case that \(i = 0\) for a broad range of cases. For example, the European Community under a unified currency/financial regime would, presumably, fall into this case. Thus, our analysis covers both cases. The case for which \(i < 0\) represents the situation where the Host government places restrictive limits on foreign direct investment. Faced with such limits a firm can use its transfer prices to indirect increase its investment in the Host market. Since studying this case requires explicit modelling of the investment opportunities in the Host market, it is beyond the scope of this paper.

\(^{12}\)The exogenous specification of the profit tax and the tariff simplify our analysis and involve no loss of generality. In a model in which the profit tax and the tariff are also set by the regulator, it is easy to demonstrate that the tariff and the subsidy are perfect substitutes for achieving any incentive feasible level of welfare and the profit tax and the subsidy are close (but imperfect) substitutes. Thus, our admittedly ad hoc focus on the role of production subsidies as a regulatory tool will not affect the general implications of our analysis.
operating profit schedule, that is as $Q = (q, \beta, \pi; t, \gamma)$. Without loss of generality we will use (1) and adopt this second definition.\textsuperscript{13}

The Host government wishes to choose a regulatory scheme that maximizes a weighted sum of expected consumer surplus, producer surplus, and tax revenues. The weights on consumer surplus and tax revenues are equal and normalized to 1 while the weight on producer surplus equals $\alpha$, where $0 \leq \alpha < 1$. If we denote gross consumer benefit by $V(q) = \int_0^q P(t) \, dt$, then the Host regulator's social welfare function equals

$$
\tilde{\theta}, \int_{\tilde{\theta}} \left\{ V(q(\tilde{\theta}(\theta))) - P(q(\tilde{\theta}(\theta)))q(\tilde{\theta}(\theta)) - S(\tilde{\theta}(\theta)) + t\tilde{\theta}(\theta)q(\tilde{\theta}(\theta)) \\
+ \left[ \gamma + \alpha(1 - \gamma)(1 - \beta(\tilde{\theta}(\theta))) \right] \pi(\tilde{\theta}(\theta)) \right\} g(\theta) \, d\theta.
$$

Using (1) to eliminate $S$ and (2) to eliminate $\theta^*_h(\theta)q(\theta^*_h(\theta))$ allows us to write the Host regulator's problem as

$$
\max_{\theta} \int_{\theta_0} \left\{ V(q(\theta^*_h(\theta))) - \theta q(\theta^*_h(\theta)) + (1 - \gamma) \left( \alpha - \frac{i}{1+i} \right) \\
(1 - \beta(\tilde{\theta}(\theta))) \pi(\tilde{\theta}(\theta)) - \frac{\tau(\theta^*_h(\theta), \theta)}{1+i} \right\} g(\theta) \, d\theta - k
$$

s.t. (a) $\tau(\theta^*_h(\theta), \theta) \geq 0$,

(b) $0 \leq \beta(\theta^*_h(\theta)) \leq 1$,

(c) $\theta^*_h(\theta) \in \arg\max_{\theta} \tau(\tilde{\theta}, \theta)$.

The rationale behind constraint (a) is that the firm can always guarantee itself zero global post-tax profits by shutting down. Thus, any feasible set of regulations must provide an adequate incentive for the firm to operate the subsidiary. Constraint (b) simply reflects the fact that the repatriation rate is a fraction between 0 and 1. Constraint (c) is the incentive compatibility constraint.

A useful benchmark is the welfare-maximizing regulatory scheme when the Host government has complete cost information. The complete information problem is defined by dropping the integral in the maximand of (4) and incentive constraint (c). We will show that honest transfer pricing is not welfare maximizing. When $\theta^*_h(\theta)$ is assumed to equal $\theta$, the complete

\textsuperscript{13}To minimize on notation the reference to $t$ and $\gamma$ will generally be omitted.
information solution is $P(q(\theta)) = \theta$, $\beta(\theta) = 0$, and $\pi(\theta) = 0$. The Host country, however, can generate greater welfare by regulating the MNE's transfer price so that it can differ from $\theta$.\footnote{Prusa's model does not formally provide the Host country with this option.} Let $\rho(\theta_{h})$ denote the regulated transfer price. Because the Host country and the MNE view operating profits and transfer-price profits as perfect substitutes ($\alpha$ and $i$ are constant), the complete information problem is unbounded. When $\alpha < i/(1 + i)$, the optimal regulations set $\pi = -\infty$ which must be offset by $\rho = +\infty$ so that $\tau = 0$. When $\alpha > i/(1 + i)$, $\pi = +\infty$ and $\rho = -\infty$. This discussion is summarized in Lemma 1.

**Lemma 1.** With complete cost information, the welfare-maximizing regulations involve marginal cost pricing, zero repatriation, and zero global profits. Moreover, if the transfer must equal actual cost, the subsidiary's operating profit equals zero while if the transfer price can differ from actual cost, either operating profit equals $+\infty$ and the transfer price equals $-\infty$ or vice versa.

Another benchmark is Prusa's solution. It is described in Lemma 2. He obtains his solution by adding to (4) the constraint, $\theta^*_{h}(\theta) = \theta$. This constraint is analogous to the restriction in the complete information problem that the transfer price equal actual cost. Call the optimization problem formed by adding this additional constraint to (4), (4'). The reasoning behind this assumption will be discussed shortly. The reader is referred to Prusa (1990) for the proof of Lemma 2.

**Lemma 2.** Assume that $\theta + G(\theta)/g(\theta)$ is increasing.\footnote{This condition is satisfied by a large class of distributions including those most often used in applications.} Then the solution to (4') satisfies: (i) $P(q(\theta)) = \theta + (1 + i)\mu(\theta)/g(\theta)$, where $\mu(\theta) = G(\theta)/(1 + i)$ if $\alpha < i/(1 + i)$ and $\mu(\theta) = (1 - \alpha)G(\theta)$ if $\alpha \geq i/(1 + i)$; (ii) $\beta(\theta) = 1$ if $\alpha < i/(1 + i)$ while $\beta(\theta) = 0$ if $\alpha \geq i/(1 + i)$; and

\[(iii) \quad \tau(\theta) = \pi(\theta) = (1 + i) \int_{w = \theta}^{\theta_{1}} q(w) \, dw.\footnote{Remember that the regulations can be functions of only the firm's report, $\theta_{h}$. However, given the additional truth-telling constraint, we know that $\theta_{h} = \theta$.}

Three features of Lemma 2 are important to note. First, marginal-cost pricing occurs only when the firm's marginal cost equals $\theta_{0}$. Second, the subsidiary's global post-tax profit equals the information rents paid to the firm by the regulator. It is strictly positive except when the firm's marginal cost equals $\theta_{1}$. In light of Lemma 1, the regulatory scheme described in Lemma 2 is clearly not first-best. Third, the justification for the additional constraint in (4') is the Revelation Principle which asserts that, for many
economic problems, there is no loss of generality in restricting attention to
regulations requiring a cost report, such as \((q, \beta, \pi)\), that induce the firm to
honestly report its private cost information. What this means is if the
Revelation Principle can be applied to \((4)\), \((4)\) and \((4')\) will be payoff
equivalent. Unfortunately, this is not true.

A quick way to verify that \((4)\) and \((4')\) are not equivalent is to note that
like its complete information counterpart in which the transfer price need not
equal actual cost, \((4)\) is unbounded. \((4')\) is not. The unboundedness arises
because none of the constraints in \((4)\) places any bounds on the term in the
maximand, \((1-\gamma)\{x-[i/(1+i)]\}(1-\beta)\pi\), and the remaining terms in the
maximand are functions of only \(q\). So if \(x-i/(1+i)>0\), the optimal operating
subsidy equals \(+\infty\) and the optimal transfer price equals \(-\infty\). Global post-
tax profits are positive and finite. If \(x-i/(1+i)<0\), the optimal subsidy
equals \(-\infty\) while the optimal transfer price equals \(+\infty\). Global post-tax
profits are the same as before. Expected welfare in either case is infinite.

The economic reason \((4)\) is unbounded is related to the fact that a dollar
of producer surplus left in the Host country is worth only \(1/(1+i)\) dollars to
the MNE. This means the MNE should be willing to pay up to \(i/(1+i)\)
dollars to repatriate this profit. Thus, \(i/(1+i)\) equals the Host government's
opportunity cost of keeping a dollar of operating profit in the country.
Whether the Host government wants to allow or enjoin repatriation depends
upon whether the value it places on a dollar of producer surplus \((x)\) is
greater or less than the opportunity cost of retaining operating profits in the
Host country. In other words, \(x-i/(1+i)\) is the Host country's marginal rate
of substitution between operating profits and transfer-price profits. Since it is
a constant in Prusa's model, these two types of profit are perfect substitutes.
Setting \(\rho=\theta\) prohibits the regulator from substituting between transfer-price
profits and operating profits and prevents unbounded solutions. Once \(\rho\) and
\(\theta\) can differ, assuming that the Host country treats both types of profits as
perfect substitutes becomes questionable on economic grounds and suggests
the need for more natural economic assumptions. We will offer a set of such
assumptions in the next section.

This initial analysis of both complete and incomplete information versions
of Prusa's model identifies the assumption that the transfer price equal actual
cost as the source of the lack of generality in Prusa's analysis. The complete
information analysis shows that the restriction is costly and the incomplete
information analysis shows that the incentive constraints need not eliminate
this cost. As a result, a certain degree of strategic transfer pricing may be
welfare enhancing.

There is a second way to understand how, by solving \((4')\) instead of \((4)\),
one overlooks some important economic costs. In order to maximize
expected welfare, the Host country must be able to control two aspects of the
MNE's activities: the size of its monopoly distortion and its cost distribution.
The latter must be controlled because the MNE's report provides it with a direct benefit from cost redistribution which in turn can lead to a reduction in welfare.\textsuperscript{17}

That is, the MNE's information rent is correlated with its output distortion (the closer the subsidiary's output to the unregulated monopoly level, the lower the MNE's information rent). To balance the welfare gains from reducing the MNE's output distortion with the attendant information costs, the Host country needs both quantity regulation and a lump-sum subsidy to achieve a second-best level of welfare. But the Host government also needs to control the MNE's cost distribution in order to present the firm with reporting incentives consistent with its welfare objectives. Problem (4') does not necessarily capture the relevant incentive costs due to the two functions the MNE's cost report plays. A simple example confirms this fact.

Suppose $\gamma = 1$. (Remember that $\gamma$ is an exogenous parameter.)\textsuperscript{18} In this case, direct revelation requires that $q(b_\gamma) = 0$. Consequently, the firm's global post-tax profit equals zero as does the Host country's welfare. Such a scheme cannot be optimal since the Host country can always decide not to regulate the firm in which case the firm earns monopoly profits and generates positive welfare levels (consumer surplus) for the Host country. Clearly, no regulation Pareto dominates any direct revelation regulation when $\gamma = 1$.

Since (4') does not account for possible 'limited-control' welfare costs, we will, in the next two sections, characterize the expected welfare-maximizing regulations and identify conditions under which the regulations $(q, \beta, \pi)$ give the Host country sufficient control over the MNE's global profits to generate second-best welfare levels. When these conditions fail to hold, the Host country can benefit from also regulating the MNE's transfer price.

3. Direct transfer price regulation

Because the Revelation Principle cannot be applied to the model in section

\textsuperscript{17}We are grateful to a referee for pointing out that direct payoff relevance of the MNE's report is not sufficient to conclude that the Revelation Principle does not hold. For example, when $\gamma = \delta = 0$, our model reduces down to Baron and Myerson's (1982) model, a model for which the Revelation Principle holds. (That is, the transfer-pricing problem is fundamentally a consequence of tax and capital interest differentials.) However, instead of asking the firm to report its cost, the government could indirectly solicit cost information by asking the firm to set output and then offer a subsidy schedule defined in terms of the firm's output choice. In this case, the firm's choice is clearly payoff relevant. In our model, direct payoff relevance becomes a factor because we are considering regulations that solicit cost information directly and because Host country welfare is affected by changes in the value of the source of this direct payoff relevance - cost redistribution.

\textsuperscript{18}The choice of $\gamma = 1$ may appear pathological. In the next section we will show that this is not the case by solving (4) for any value of $\gamma$ (and $a$, $i$, and $t$). The sole purpose of setting $\gamma = 1$ at this point in the paper is to provide a very simple example to help convince the reader that something is amiss with the application of the Revelation Principle in Prusa's paper.
2, another method is needed for working with the complex association between a government’s choice of regulations, the MNE’s cost report, and the consequent effect on the country’s welfare. In this section we augment the set of instruments available to the Host government by assuming it sets \( \rho \), the MNE’s transfer price, as well as \((q, \beta, \pi)\). Giving the Host government control over the firm’s transfer price breaks the link between the MNE’s cost report and cost distribution and gives the Host government full control of the MNE’s global profits. Alternatively, we could assume that the government offers the MNE a fully repatriatable subsidy, \( \rho q \), and a partially repatriatable subsidy, \( S \).\(^{19}\)

Allowing \( \rho \) to differ from \( \theta \) gives the Host regulator greater flexibility in deciding how the MNE will earn its information rents. Before, the information rents took the form of greater operating profits. Now, the MNE can collect information rents either as operating profits or as transfer-price profits. Moreover, since negative operating profits or negative transfer-price profits (but not both) are now possible, we must take account of certain economic costs that are inconsequential in a model that proscribes non-zero transfer-price profits.\(^{20}\) The modifications to Prusa’s model which we use to account for these costs are described below.

First, we consider changes related to the possibility that \( \pi < 0 \). Given \((q, \beta, \pi, \rho)\), the subsidiary’s operating profit equals

\[
\pi(\theta_h) = P(q(\theta_h))q(\theta_h) - (1 + \tau)\rho(\theta_h)q(\theta_h) - k + S(\theta_h). \tag{5}
\]

If \( \pi > 0 \), the MNE’s global post-tax profit equals

\[
\tau(\theta_h, \theta) = (1 + i)(\rho(\theta_h) - \theta)q(\theta_h) + (1 - \gamma)(1 + \beta(\theta_h)i)\pi(\theta_h). \tag{6}
\]

On the other hand, if \( \pi \leq 0 \), the profit tax and repatriation rate are no longer relevant (effectively, \( \gamma = 0 \) and \( \beta = 1 \)) and

\[
\tau(\theta_h, \theta) = (1 + i)[(\rho(\theta_h) - \theta)q(\theta_h) + \pi(\theta_h)]. \tag{7}
\]

Eq. (7) implies that the MNE must repatriate its subsidiary’s losses. Without this assumption, the subsidiary would have to find alternative financial resources when \( \pi < 0 \) or close down. In reality, then, our assumption is that the MNE is the subsidiary’s only external source of funds. As long as \( \tau > 0 \)

\(^{19}\)We thank one of the referees for this interpretation.

\(^{20}\)Negative transfer-price profits provide an alternative channel for increased foreign direct investment, something an MNE would be willing to consider if its subsidiary’s operations were suitably rewarded. At the same time an MNE would be willing to accept regulations that imply negative economic operating profits for its subsidiary if the transfer-price regulations provided adequate transfer-price profits. Empirical evidence for both types of trade-offs can be found in Alworth (1988), Rugman and Eden (1985), and Razin and Slemrod (1990).
for almost all \( \theta \), the MNE will want to repatriate subsidiary losses to maintain an ongoing concern and the opportunity cost of each dollar of such support is \( 1+i \).

There is also the issue of how negative producer surplus enters the Host country's welfare function. We prefer to think of \( \alpha \) as the opportunity cost of producer surplus when \( \pi<0 \). For our model there is no loss of generality in assuming that \( \alpha \) is a constant for all \( \pi \leq 0 \).

Second, we consider changes related to the possibility of negative transfer-price profits that arise when \( \rho<\theta \). Here we dispense with the assumption that consumer and producer surplus are perfect substitutes as implied by the constant weight put on producer surplus in the Host country's welfare function. The reason for assuming a decreasing marginal rate of substitution between consumer and producer surplus is that larger transfer-price losses must necessarily be coupled with larger operating profits in order to cover the MNE's information rents. Larger operating profits at some point can only be achieved via larger operating subsidies and large subsidies carry with them non-trivial economic costs. These include opportunity costs that reflect general equilibrium distortions when the Host government raises the subsidy with taxes and a capital market distortion when it raises the subsidy by borrowing. In addition one can also expect that the marginal benefit of producer surplus is decreasing and that the marginal cost of producer surplus due to increased political instability is increasing. Individually or together these reasons imply that consumer and producer surplus are not perfect substitutes. Alternatively one could point out that negative transfer-price profits imply increased capital investment in the subsidiary and that this additional capital will eventually generate increasing opportunity costs for the MNE because of capital market imperfections. That is, if the capital investment in the subsidiary is large enough, the MNE will need to borrow funds. Imperfect capital markets imply an increasing marginal cost of these funds. All three of these costs, increasing marginal opportunity costs of capital for the MNE, increasing marginal costs of subsidy dollars for the Host government, and a decreasing marginal rate of substitution between consumer and producer surplus, affect the relative returns to various levels of regulation in similar ways. In order to limit the complexity of the model, we will only model the last of these three costs by assuming that for \( \pi > 0 \), the weight on producer surplus is a function of the subsidiary's operating profits.

**Assumption 1.** (i) \( 0 \leq \alpha(0) \leq 1 \), (ii) \( \alpha(\infty) = 0 \), and (iii) \( \alpha'(\pi) < 0 \) for \( \pi \geq 0 \).

**Assumption 2.** (i) \( \alpha \) is continuously differentiable and (ii) \( \pi(\theta) = \hat{\pi} \) uniquely maximizes \( \{\alpha(\pi(\theta)) - i/(1+i)\}\pi(\theta) \) when \( \alpha(0) > i/(1+i) \).

Assumption 1 requires that the net marginal benefit of producer surplus is
initially positive, that it is generally less than the marginal benefit of consumer surplus, that it is strictly decreasing, and that it converges to 0. Assumption 2 is included to simplify the technical exposition.

These assumptions naturally bound the Host country’s problem. Recognizing the different tax and repatriation treatments of negative operating profits bounds the problem from below while allowing for a variable weight on producer surplus bounds the problem from above.

Finally we modify Prusa’s model by assuming that $\beta = 0$. If $\beta$ was chosen endogenously, its optimal value would either be 0 or its value would be irrelevant (with one exception that we will mention below). Thus we exogenously set $\beta$ to 0 to economize on notation.

Together these changes alter the Host country’s social welfare function. Let $W(q(\theta_h), \pi(\theta_h), \rho(\theta_h), \theta)$ denote this welfare function for a reported cost of $\theta_h$ and a true cost of $\theta$. Combining these changes with (5), (6), and (7) implies that if $\pi(\theta_h) > 0$,

$$W = V(q(\theta_h)) - \theta q(\theta_h) + (1 - \gamma) \left( \pi(\theta_h)(1 + i) - \tau(\theta_h, \theta) \right) - k,$$  (8)

and if $\pi(\theta_h) \leq 0$,

$$W = V(q(\theta_h)) - \theta q(\theta_h) + \pi(\theta_h)(1 + i) - \tau(\theta_h, \theta) - k.$$  (9)

Of course, the most important change in this section is letting the Host government set the MNE’s transfer price. Since the MNE’s cost report is no longer directly payoff relevant we can, without loss of generality, invoke the Revelation Principle and restrict attention to direct revelation regulations. Lemma 3 characterizes these regulations.\(^21\)

**Lemma 3.** The regulations $(q, \beta, \pi, \rho)$ are direct revelation regulations if, and only if,

$$\tau'(\theta) \equiv \frac{d \tau(\theta, \theta)}{d \theta} = -(1 + i)q(\theta)$$  (10)

and

$$q'(\theta) \leq 0.$$  (11)

Intuitively, (10) tells us that to support honest reporting, the firm’s global post-tax profits must be negatively correlated with its cost report and (11)

\(^21\)Prusa’s (1990) proof of his Proposition 2 is analogous to the proof of Lemma 3.
tells us that higher cost reports must result in lower output levels. In light of Lemma 3, let \( \tau(\theta) \equiv \tau(\theta, \theta) \).

We can now write down the Host country's optimization problem as

\[
\max_{\theta} \int_{\theta_0}^{\theta_1} W(q(\theta), \pi(\theta), \tau(\theta, \theta)g(\theta)) \, d\theta
\]

s.t. (a) \( \tau(\theta, \theta) \geq 0 \),
(b) \( \tau'(\theta) = -(1 + i)q(\theta) \),
(c) \( q'(\theta) \leq 0 \).

The easiest way to solve (12) is to drop constraint (c) and then verify that it is satisfied by the solution. Theorem 1 describes the regulations that solve (12). The proof is in Appendix A.

**Theorem 1.** Assume that \( \theta + G(\theta)/g(\theta) \) is increasing. \(^{22}\) Let \((q^*, p^*, \pi^*)\) denote the solution to (12) and let \( \tau^* \) denote the MNE's global post-tax profit given \((q^*, p^*, \pi^*)\). Then

\[
P(q^*(\theta)) = \theta + G(\theta)/g(\theta),
\]

\[
\tau^*(\theta) = (1 + i) \int_{\omega_0}^{\theta_0} q^*(\omega) \, d\omega,
\]

and

\[
p^*(\theta) = \theta + \frac{\tau^*(\theta)}{(1 + i)q^*(\theta)} - \frac{1 - \gamma}{1 + i} \pi^*(\theta).
\]

For \( \alpha(0) \leq i/(1 + i) \), \( \pi^*(\theta) = 0 \). For \( \alpha(0) > i/(1 + i) \), \( \pi^*(\theta) = \pi^* \) and \( \alpha(\pi^*) + \alpha'(\pi^*) \pi^* = i/(1 + i) \).

The economic reason that two cases arise was discussed earlier in reference to the unboundedness problem. Regardless of which case we wish to discuss, Lemma 3 makes it quite clear that the MNE must earn cost-information rents and hence non-negative global post-tax profits. As a result the Host government must address two questions: How large should the MNE’s information rents be? What is the optimal distribution of these rents between transfer-price profits and operating profits? For the first question the problem is that in welfare terms the Host country would like to increase market output up to the first-best level of Lemma 1. However, as the Host government increases output beyond the unconstrained monopoly level, the

\(^{22}\)This condition, which is satisfied by many common densities, ensures that the solution satisfies constraint (12c). See Baron and Myerson (1984) or Prusa (1990) for details.
information rents due the firm also increase. Thus, the output schedule should only be increased out to the point where the marginal gain in surplus equals the Host country’s marginal cost of the MNE’s information rents. That is what the pricing rules accomplish.

Up to this point there are only minor differences between Prusa’s solution in Lemma 2 and the solution above in Theorem 1. Where the two solutions differ, however, is in the way the Host government allows or encourages the MNE to collect its information rents. By assuming that \( \rho(\theta) = \theta \), Prusa was effectively requiring the Host government to pay the MNE all of its rents via a production subsidy. The following corollary identifies the expected welfare costs of this assumption. Its proof is in Appendix A.

\[
\text{Corollary 1. Let } \theta + G(\theta)/g(\theta) \text{ be increasing. If } \alpha(0) < i/(1 + i), \text{ then for all } \theta \in [\theta_0, \theta_1], \rho^*(\theta) > \theta \text{ and } (\rho^*)'(\theta) > 0. \text{ For } \alpha(0) > i(1 + i), \text{ let } \theta = \min \{ \theta \mid \gamma^*(\theta) \leq (1 - \gamma)\pi \}. \text{ Then for all } \theta < \theta, \rho^*(\theta) > \theta \text{ and } (\rho^*)'(\theta) > 0, \text{ and for all } \theta > \theta, \rho^*(\theta) < \theta \text{ and } (\rho^*)'(\theta) < 0.
\]

Corollary 1 makes it clear that a policy that induces honest transfer pricing for any level of true costs \( \theta \) is never welfare maximizing. In addition, if the marginal value of producer surplus starts out greater than \( i/(1 + i) \) and decreases fast enough, then the optimal regulations may include both positive transfer-price profits and positive operating profits. If the rate of decrease is slower, then the Host country will elect to use operating profits exclusively to pay the MNE its information rents.

It is important to note that if the repatriation rate, \( \beta \), is set endogenously, then when \( \alpha(0) \leq i/(1 + i) \), another set of solutions emerges. In this case, \( \beta = 1 \) and any value of \( \pi(\theta) \) is optimal. The implication of this result is that \( \rho(\theta) < \theta, \rho(\theta) = \theta, \rho(\theta) > \theta \), or any combination of these possibilities can be consistent with expected welfare maximization. In particular, the component of Prusa’s solution when \( \alpha < i/(1 + i) \) is optimal. These alternative solutions would disappear if the profit tax is levied on positive accounting profits instead of just positive economic profits (or at least to some arbitrarily small fraction of economic profits less accounting profits). It would also be true in this case that the optimal regulations would result in zero accounting profits for the subsidiary. In this way these alternative solutions can be viewed as knife-edge solutions.

The optimal transfer-price behavior also does not correspond to the limit transfer-pricing strategies found in the complete-information models of Copithorne (1971) and Diewert (1985). With limit transfer pricing the MNE’s transfer price equals either \( \theta_0 \) or \( \theta_1 \). Limit transfer pricing is also found in Prusa’s Proposition 1, but then only as the MNE’s response to fixed, ad hoc repatriation and subsidy levels. Given the model used in this section, limit transfer pricing cannot be optimal because it is impossible for \( \rho^*(\theta) \geq \theta_1 \) for
all $\theta$ when $\alpha(0) \leq i/(1 + i)$. However, if the profit tax is levied on positive accounting profits rather than positive economic profits and if $\rho \in [\theta_0, \theta_1]$, conditions exist under which limit transfer-pricing behavior is welfare maximizing. This change requires that we assume $k = k^a + k^o$, where $k^a$ equals the accounting cost of the MNE's fixed investment and $k^o$ equals the opportunity cost of the MNE’s fixed investment. If $|\alpha'(\cdot)|$ is sufficiently small and $k^o$ is sufficiently large, then the optimal transfer price equals either $\theta_0$ or $\theta_1$. When $\alpha(0) > i/(1 + i)$, the slower the rate at which the marginal benefit of producer surplus decreases as the level of produce surplus increases, the higher is the optimal level of operating profit for the subsidiary. If this operating profit level is sufficiently large, the optimal regulations will imply $\rho(\theta) \leq \theta_0$. But since we now require $\rho \geq \theta_0$, $\rho$ will equal $\theta_0$. When $\alpha(0) \leq i/(1 + i)$, negative economic operating profits implies positive transfer-price profits. Since the optimal regulations do not cover $k^o$ with operating profits they must be covered with transfer-price profits. Thus, $\rho$ will be larger the larger $k^o$. But $\rho \leq \theta_1$. So if $k^o$ is large enough, $\rho(\theta) = \theta_1$. Consequently, conditions exist under which limit transfer pricing can be seen as an optimal policy given a profit tax on accounting profit and an exogenous requirement that the MNE's transfer price agree with the support of the Host country's beliefs.

4. Indirect transfer price regulation

Instead of adopting direct transfer price regulations, governments often use regulations that allow the MNE to set its transfer price but provide incentives that ‘guide’ the MNE’s choice. Such indirect regulations, however, reintroduce the Revelation Principle problems identified in section 2. In this section we characterize optimal indirect transfer-price regulations and compare their welfare properties with the optimal direct regulations of section 3. The approach we use is due to Mirrlees (1971). It involves first writing (4), with the assumptions from section 3 used to bound the problem, in terms of what we will call performance targets. This new problem differs from (12) in that it does not restrict attention to regulations that induce truth-telling. We then solve for the optimal performance targets and derive the regulations $Q = (q, \pi)$ that implement these targets.$^{23}$

We need to define two targets, one for each regulatory instrument. Denote these targets by $\delta = (\delta_q, \delta_\pi)$ where

$$\delta_q(\theta) = q(\theta^*_q(\theta)) \quad \text{and} \quad \delta_\pi(\theta) = \pi(\theta^*_\pi(\theta)).$$

These performances targets specify the output and operating profit levels the Host government would like to realize for each value of $\theta$ given the MNE's

$^{23}$We will continue to assume that $\beta = 0$.
optimal transfer-price strategy \( \theta^*_h(\theta) \).\(^{24}\) Certainly, if we start with a set of regulations, it is possible to derive the corresponding performance targets. However, we need to work in the opposite direction. That is, given some performance targets we need to associate them with regulations that satisfy (13). We will call the targets \( \delta \) incentive compatible if, and only if, there exist regulations \( Q \) such that (13) holds. If such a set of regulations exists, we will say that \( Q \) implements \( \delta \). If \( Q = \delta \), then \( Q \) is a set of direct revelation regulations.

If we ignore the implementation issue for a moment, it turns out that the optimal targets, \( \delta^* = (\delta^*_e, \delta^*_s) \), coincide with the optimal regulations of Theorem 1. That is, \( \delta^*_e(\theta) = q^*(\theta) \) and \( \delta^*_s(\theta) = \pi^*(\theta) \). If \( \delta^* \) is incentive compatible, then it must also be true that \( \theta^*_h(\theta) = \rho^*(\theta) \). Since \( q^*(\theta) \) is strictly decreasing, a necessary and sufficient condition for implementation is that \( \rho^* \) be invertible. According to Corollary 1, this is true only when \( \alpha(0) \leq i/(1 + i) \) or when \( \alpha(0) > i/(1 + i) \) and \( (1 - \gamma)\pi \geq \tau^*(\theta_0) \) because these conditions are necessary and sufficient for \( \rho^* \) to be strictly monotonic. In both cases, the optimal direct and indirect regulations are welfare equivalent, i.e. they generate the same market price, the same operating and transfer-price profits, and the same transfer prices. Still \( \delta^* \) only defines target quantity and operating profit levels. The actual regulations that implement these targets, call them \( q^* \) and \( \pi^* \), are those that satisfy (13) and for which

\[
\frac{\partial \tau^*(\theta_h, \theta)}{\partial \theta_h} = 0, \tag{14}
\]

where

\[
\tau(\theta_h, \theta) = (1 + i)(\theta_h - \theta)q(\theta_h) + (1 - \gamma)\pi(\theta_h) \tag{15}
\]

when \( \pi(\theta_h) > 0 \) and

\[
\tau(\theta_h, \theta) = (1 + i)[(\theta_h - \theta)q(\theta_h) + \pi(\theta_h)] \tag{16}
\]

when \( \pi(\theta_h) \leq 0 \). Eq. (14) is the first-order condition for \( \theta^*_h(\theta) \) to be a profit-maximizing reporting strategy. Because \( \pi^*(\theta) \) is a constant in both cases, (13) can only be satisfied if \( \pi^*(\theta_h) = 0 \) when \( \alpha(0) \leq i/(1 + i) \) and if \( \pi^*(\theta_h) = \pi \) when \( \alpha(0) > i/(1 + i) \). Moreover, \( \pi^*(\theta) \) constant implies that (14) is equivalent to

\[
q(\theta^*_e(\theta)) + (\theta^*_s(\theta) - \theta)q'(\theta^*_h(\theta)) = 0. \tag{17}
\]

\(^{24}\)Because \( P(\cdot) \) is common knowledge and strictly decreasing, one can alternatively think of indirect transfer pricing as price regulation in the final good market.
The solution to the differential equation in (17) defines $q^*(\theta_n)$. The details are provided in the Appendix B.

In the remaining case, $p^*$ does not fully separate or distinguish among different cost levels, $\theta$, even though $q^*$ requires full separation. Although describing the optimal indirect regulations for this third case must be left for future research, it is possible to conclude from the above discussion that in this case the optimal direct regulations generate strictly greater expected welfare than the optimal indirect regulations.\textsuperscript{25} Theorem 2 summarizes this discussion.

Theorem 2. If $\alpha(0) \leq i/(1+i)$ or $\alpha(0) > i/(1+i)$ and $(1-\gamma)i \geq \pi^*(\theta_0)$, then the expected welfare-maximizing direct regulations and the expected welfare-maximizing indirect regulations are welfare and profit equivalent. If $\alpha(0) > i/(1+i)$ and $(1-\gamma)i < \pi^*(\theta_0)$, then the Host country strictly prefers the expected welfare-maximizing direct regulations over the expected welfare-maximizing indirect regulations.

5. Conclusion

When we talk about international transfer pricing, the most common example associates the United States with the Home country and some developing country with the Host. However, recent events like 'Europe 1992' and the establishment of productive capacity by Japanese firms in the United States will quickly, if they have not already, upset these stereotypes. Recent congressional concern over the transfer-price practices of the Japanese suggests that confronting these issues from the perspective of the Host government is already a very real issue in U.S. trade policy. While our analysis of the problem is far from complete, we believe our work makes several important points.

First, the fact that the MNE's transfer has both direct and indirect payoff relevance can invalidate studies arising from a standard application of the Revelation Principle. To address this fundamental problem in the study of strategic trade issues the transfer price must either be placed under the direct control of the Host government or the optimal regulations that allow the MNE to control its transfer price must be defined using techniques common to the optimal taxation literature.

\textsuperscript{25}We thank one of the referees for pointing out a problem related to this fact in an earlier draft.

\textsuperscript{26}The same problem arises in the model variant in which limit transfer pricing emerges as an optimal direct policy. Since $(\rho^*)'\theta = 0$, the MNE's cost report under indirect regulation is uninformative. As a result, all indirect regulations generate fewer welfare gains than the best direct regulation.
Second, although international transfer pricing necessarily creates opportunities to skirt local tax policies and other financial regulations it also creates an opportunity for a Host government to induce compliance with its regulations in a way that reduces the welfare costs of the information rents the MNE will inevitably collect. As long as the Host government places sufficient value on producer surplus, any attempt to eliminate the incentives that encourage a firm to distort its transfer prices and that also fail to eliminate the underlying incomplete information problems will result in lower welfare for the Host country.

Third, given that tariffs on imported intermediate goods often have distortionary effects from a general equilibrium perspective, they should be eliminated since in both cases they serve only to increase the subsidy the government must pay the firm. Moreover, for each dollar collected via a tariff, the subsidy must be increased by a dollar.

Fourth, the direction in which the firm strategically manipulates its price is directly related to the Host country's attitudes towards producer surplus. With a sufficiently strong value placed on producer surplus, the Host country benefits from regulations that increase the level of foreign direct investment it receives.

Fifth, while there can exist an equivalence between the optimal direct and indirect regulations, one need not exist in general.

A number of areas of future research are also suggested by our results. Among them we mention two that we will pursue in future papers. First, in this paper we studied optimal regulation of a foreign-owned subsidiary that operates as a monopolist. If instead the subsidiary faces local competition, the set of regulatory instruments available to the Host government may change and competition may diminish the value of the MNE's private information. These changes may then alter the structure of optimal transfer-pricing regulation. Second, the regulation of a MNE by a Host country may create incentives for the Home country to offer the parent company countervailing incentives. Thus, the regulation of an MNE might best be viewed as a problem of common agency since both countries can influence the firm's behavior through the choice of local regulations. Given this potential interaction among competing regulations it may be important to delineate when it is appropriate to analyze a firm's transfer-price activities as a pair of disjoint principal-agent problems and when it is necessary to adopt an integrated common agency approach. For examples of this type of problem see Baron (1985), Gal-Or (1991), van Egteren (1991) and Stole (1992).

Appendix A: Proofs

Proof of Theorem 1. The Hamiltonian associated with (12) is
\[ H = W(q, \pi, \tau, \theta)g(\theta) - \mu(\theta)(1 + i)q(\theta), \]

where \( \tau \) is the state variable, \( \mu \) is the co-state variable, \( q \) and \( \pi \) are the controls, and

\[
W(q, \pi, \tau, \theta) =
\begin{cases}
V(q(\theta)) - \theta q(\theta) - \tau \frac{\pi(\theta)}{1 + i} + (1 - \gamma) \left( \pi(\theta) - \frac{i}{1 + i} \right) \pi(\theta) - k, & \text{if } \pi(\theta) > 0, \\
V(q(\theta)) - \theta q(\theta) - \tau \frac{\pi(\theta)}{1 + i} + \pi(\theta)\pi(\theta) - k, & \text{if } \pi(\theta) \leq 0.
\end{cases}
\]

The Euler conditions with respect to \( q \) and \( \tau \) are

\[
(P(q(\theta)) - \theta g(\theta) - \mu(\theta)(1 + i)) = 0 \quad (A.1)
\]

and

\[
\mu'(\theta) = \frac{g(\theta)}{1 + i}. \quad (A.2)
\]

Eq. (A.2) implies that \( \mu(\theta) = \frac{G(\theta)}{1 + i} \). Thus, (A.1) implies that

\[
P(q^*(\theta)) = \theta + \frac{G(\theta)}{g(\theta)}. \quad (A.3)
\]

When \( \alpha(0) < \frac{i}{(1 + i)} \), \( W_\pi < 0 \) for \( \pi > 0 \) and \( W_\pi > 0 \) for \( \pi \leq 0 \). Thus, \( \pi^*(\theta) = 0 \).

When \( \alpha(0) > \frac{i}{(1 + i)} \), \( W_\pi > 0 \) for \( \pi = 0^+ \). Hence, \( \pi^*(\theta) > 0 \) and satisfies

\[
\alpha'(\pi(\theta))\pi(\theta) + \alpha(\pi(\theta)) = \frac{i}{(1 + i)}. \quad (A.3)
\]

For this latter case, let \( \Gamma(\pi) = (\alpha(\pi) - \frac{i}{(1 + i)})\pi \). Because \( \Gamma(0) = 0 \), because there exists a \( \pi^* \) such that for all \( \pi > \pi^* \), \( \Gamma(\pi) \leq 0 \), and because \( \Gamma'(0) > 0 \), a local maximum of \( \Gamma \) (and hence \( H \)) exists. Therefore a global maximum also exists and must satisfy (A.3). Finally, \( P' \leq 0 \) guarantees that the second-order conditions for a maximization are also satisfied.

\[ \tau^*(\theta, \theta) \text{ can be derived from (10) and by noting that the implicit transversality condition requires that } \tau^*(\theta_1, \theta_1) = 0. \]

Finally, if \( \theta + G(\theta)/g(\theta) \) is non-decreasing, then \( q'(\theta) \leq 0 \). Given Lemma 3, \( (q^*, \pi^*, \rho^*) \) must be direct revelation regulations. Q.E.D.

**Proof of Corollary 1.** Given Theorem 1, (6), and (7),
\[ \rho^*(\theta) = \theta + \frac{\pi^*(\theta)}{(1+i)q^*(\theta)} \]  
(A.4)

and

\[ (\rho^*)'(\theta) = -\frac{\pi^*(\theta) (q^*)'(\theta)}{(1+i)q^*(\theta)^2} \]  
(A.5)

if \( \alpha(0) \leq i/(1+i) \); while

\[ \rho^*(\theta) = \theta + \frac{\pi^*(\theta) - (1-\gamma)\hat{\pi}}{(1+i)q^*(\theta)} \]  
(A.6)

and

\[ (\rho^*)'(\theta) = \frac{(q^*)'(\theta)}{(1+i)q^*(\theta)^2} [(1-\gamma)\hat{\pi} - \pi^*(\theta)]. \]  
(A.7)

if \( \alpha(0) > i/(1+i) \). Thus, \( \rho^*(\theta) > \theta \) in (A.4) and as \( (q^*)'(\theta) < 0, (\rho^*)'(\theta) > 0 \) in (A.5). The signs of both \( \rho^*(\theta) - \theta \) from (A.6) and \( (\rho^*)'(\theta) \) from (A.7) equal the sign of \( \pi^*(\theta) - (1-\gamma)\hat{\pi} \). Q.E.D.

Appendix B: The solution to differential equation (17) – The optimal indirect quantity schedule

Because \( \delta^q_\theta(\theta) < 0 \) and because there are no exogenous bounds on the MNE’s reported transfer price, (17) is both necessary and sufficient for implementation. Part of the difficulty in solving (17) is the fact that \( \theta^*_q(\theta) \) depends on \( q \).

To solve (17) multiply both sides by \( (\theta^*_q(\theta)') \), which equals \( (\rho^*)'(\theta) \), and thus is non-zero by Corollary 1. Then substitute (13) into (17) noting that \( \theta^*_q(\theta) = q^{-1}(\delta^q_\theta(\theta)) \) and \( (\theta^*_q(\theta)') = (q^{-1})(\delta^q_\theta(\theta))\delta^q_\theta(\theta) \), where \( \delta^q_\theta(\theta) = q^*(\theta) \). This yields

\[ \frac{d}{d\theta} [\delta^q_\theta(\theta)q^{-1}(\delta^q_\theta(\theta))] = \theta \delta^q_\theta(\theta). \]  
(B.1)

(B.1) is an ordinary differential equation in \( q^{-1}(\cdot) \) the solution of which is

\[ \omega q^{-1}(w) = \delta^q_\theta(\theta_1)q^{-1}(\delta^q_\theta(\theta_1)) - \int_{x = \delta^q_\theta^{-1}(w)}^{\theta_1} x\delta^q_\theta'(x) \, dx. \]

The initial condition
ensures that \( \tau(\theta_0^*(\theta_1), \theta_1) = 0 \).

References


Raff, H., 1991, Intra-firm exports and optimal host country commercial policy under asymmetric information, Mimeo. (Université Laval).
Stole, L., 1992, Mechanism design under common agency, Mimeo. (University of Chicago, Chicago, IL).
Stoughton, N. and E. Taylor, 1991, A mechanism design approach to transfer pricing by the multinational firm, Mimeo. (University of California, Irvine, CA).