Vertically integrated multinationals: a microeconomic analysis

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INTRODUCTION

One important topic in the literature on the pricing policies of vertically integrated multinational corporations has been the choice of a transfer price, the price charged by one affiliate of a multinational in commodity transactions with another affiliate of the same enterprise. Models of transfer pricing have been built by Hirshleifer (1956, 1957), Solomons (1965), and Copithorne (1971, 1976). Hirshleifer and Solomons were concerned with developing the shadow price for trade between divisions located in the same country as the parent firm. Their analysis has been extended by Copithorne (1971) into the international field by considering three firms, each located in a different country, where primary intrafirm trade occurs. In his 1976 paper, assuming that international tariff and tax differentials constrain the multinational, Copithorne has shown that the products transferred between divisions may have two transfer prices, an internal shadow price based on marginal cost, and an external price for tax and tariff authorities. The shadow price can be obtained without any reference to the money transfer price except where costs and revenues of the corporation are affected by these transfer prices.

In this paper the Copithorne model is first developed under the assumptions of free trade among the corporation's subsidiaries to include intrafirm trade in both primary products and secondary products. Then the model is expanded to deal with the effects caused by the introduction of profit taxes and tariffs. The aim of the paper is to show how profit taxes and tariffs through the influence of money transfer prices constrain the multinational enterprise (or MNE) and cause it to alter its resources allocation decisions. One of the contributions of this paper is to deal with secondary trade among subsidiaries, a subject omitted by the other literature cited.[1] By affecting cost and revenue functions, money transfer prices can affect the shadow prices of primary and secondary output and therefore affect intrafirm trade flows by both primary and secondary divisions.[2]

This paper is drawn from my dissertation (Eden, 1976), written under the direction of Carl Shoup, professor emeritus, Columbia University, and Cliff Walsh, Australian National University. Two anonymous referees also made valuable comments. The responsibility for errors is my own.

1 Primary trade between subsidiaries of a multinational corporation occurs when one subsidiary sells its product to a second subsidiary. Secondary trade occurs when this product is then sold by the second subsidiary to a third. Normally there is some value added by the second subsidiary.

2 Trade between the secondary (or final) product firms can occur if the primary good is transformed into a different product. For example, if the primary division produces

THE MODEL UNDER FREE TRADE

Assume the MNE consists of three firms, firm 3, the primary firm, and firms 1 and 2, the secondary firms. The primary firm sells only to the secondary firms[3] and faces increasing production costs. Units of measure are chosen so that one unit of raw material is needed to produce one unit of finished output.[4] The final products of the secondary firms are identical. The goal of the corporation is to maximize long-run total corporate profits. Both secondary firms have some market power in their domestic markets in that they both face downward-sloping demand curves. Price discrimination between markets is possible. Where marginal cost and marginal revenue differentials exist, profitable intra-firm secondary trade is possible.

As shown in appendix A, the basic condition under free trade that must be satisfied if long-run total corporate profits are to be maximized is

$$MR_1 = MC_1 + MC_3 = MR_2 = MC_2 + MC_3, \tag{1}$$

where MR_i refers to the marginal revenue from domestic sales Y_i of firm i, and MC_i to the marginal cost of domestically produced output X_i of firm i. That is, the corporation must equate the marginal revenues from final product sales to marginal secondary production costs plus the marginal cost of the primary inputs. Since marginal primary cost is determined by the total output of firm 3, X_3 (or by the total purchases of firms 1 and 2, $Y_1 + Y_2$) this cost is identical for the secondary firms.[5]

The basic conditions not only determines total corporate output and sales levels but also contains two subconditions that show how these sales and output totals should be distributed between the secondary divisions:

$$MR_1 = MR_2, \tag{2}$$

by which the corporation will increase profits by reallocating secondary product between the two secondary firms so as to equate the marginal revenues from

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wood pulp which is transformed into newsprint by the secondary firms, then this newsprint could be traded between the final product divisions depending on their cost and revenue functions and transport costs. Refined petroleum products are another example.

3 This is a common assumption in the literature cited above. Copithorne (1971, 325n.) notes the conditions under which the secondary firms can purchase externally rather than buying from the primary firm.

4 This is an assumption of Copithorne's. Letting X_1 be the output of firm 1, X_2 be the output of firm 2, and X_3 be the output of firm 3, then $X_1 + X_2 = X_3$. That is, the amount of X_3 produced and sold by firm 3 equals the amount of $X_1 + X_2$ produced and sold by the secondary firms.

5 This condition is similar to Hirshleifer's, Solomons's, and Copithorne's profit-maximizing condition, which is: $MR_1 - MC_1 = MC_3 = MR_2 - MC_2$. However, in their models $X_i = Y_i$, so MR_i and MC_i are determined at the same output and sales levels. In this paper X_i is not equal to Y_i when the secondary firms engage in trade between each other.

domestic secondary sales shifting sales from the low-revenue market to the high-revenue market, and

$$MC_1 = MC_2, \tag{3}$$

by which the corporation will increase profits by allocating primary product deliveries to the secondary firms so as to equate marginal secondary production costs.

These subconditions can be explained as follows: if there are differences in marginal processing costs and marginal revenues between the secondary firms, profits can be increased through changes in intrafirm trade. Through trade in the secondary product, sales can be reallocated from the low-revenue market to the high-revenue market, bringing marginal revenues into equality and raising total corporate revenues. Through a reallocation of trade in the primary product, secondary processing can be reallocated from the high-cost processing plant to the low-cost one, bringing marginal processing costs into equality and lowering total corporate costs. And finally, the global level of output (governed by the level of production of the primary product) can be chosen so that marginal revenue equals the sum of the marginal primary costs and marginal secondary costs.

Money transfer prices do not influence total output and sales, their allocation between the secondary firms, nor the total profit enjoyed by the corporation (because they cancel out through the MNE's objective function). However, they do determine the allocation of profits among the three firms (see appendix A). There are four possible money transfer prices in this model: PM_{12}, PM_{21}, PM_{31}, and PM_{32}. Even though the marginal cost of the primary good MC_3, the true shadow transfer price, is identical for both firms, the money transfer prices charged to firms 1 and 2 by firm 3 need bear no relation to this shadow price; nor need they be identical for the secondary firms. Similarly, the shadow price for secondary exports, which is the marginal processing cost in the exporting secondary division, need not be the basis for the money price paid by the importer.

THE MODEL UNDER TARIFF BARRIERS

A tariff on secondary imports
One constraint on multinational behaviour is tariff barriers. These can be imposed on secondary or primary imports or both. The results will differ depending on the level of tariff and the flexibility of money transfer prices. Assume, first, that country 2 levies an ad valorem tariff on secondary imports at rate r_1. Since firm 2 imports finished goods only from firm 1 the per unit tariff is r_1PM_{12}.[6] Generally one would expect the tariff to drive a wedge between

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6 If the multinational lowers its money transfer price in order to reduce its tariff costs, this is shown as a smaller per-unit tariff. Or, if the price charged for these imports is not accepted by the customs authorities, assume the tariff includes this readjustment of money transfer prices.

the marginal revenues of firms 1 and 2 and force the MNE to alter its allocation decisions in order to minimize these tariff costs (see equations A.5 and A.6). The lower the per-unit tariff, the less disturbance to total output and sales and to their allocation, to prices, factor flows, and profits. One would predict, a priori, that the MNE would attempt to set as low a money transfer price as possible, with the optimal price being zero.[7] If this is not feasible because of government restrictions, the enterprise would reduce the volume of trade between the secondary firms. Normally the transfer price will be at least partly under the company's control, although for the purposes of this model it is assumed to be fixed.

The profit-maximizing condition when a tariff is levied by country 2 on secondary imports (assuming firm 1 is the exporter of the secondary good) is

$$MR_1 + r_1 PM_{12} = MC_1 + r_1 PM_{12} + MC_3 = MR_2 = MC_2 + MC_3. \tag{4}$$

This condition determines the total output produced and sold by the multinational.[8] Introducing the tariff will cause a fall in the profitability of marginal output and hence a contraction in total corporates output and sales. Since, by assumption, $X_3 = X_1 + X_2$, primary intrafirm trade flows also contract.

The tariff has a trade-contracting effect on secondary trade flows as well as on primary flows. Assuming firm 1 was initially the low-cost, low-revenue firm (when marginal costs and revenues are measured at the no-trade position), the tariff lowers the revenues firm 1 can earn from exports, so that the incentive to export is reduced. Secondary trade will contract and can even cease if the tariff is prohibitive. By reducing the trade flow the MNE has reduced its tariff costs. If money transfer prices are under the MNE's control, lowering the transfer price both lowers tariff costs and reduces distortions in corporate output and sales levels.

A tariff on primary imports

If, instead of levying a tariff on finished imports, the government of country 2 places an ad valorem duty of r_3 per cent on raw material imports, the multinational is faced with a tariff on firm 2's imports from firm 3 at the rate of $r_3 PM_{32}$ per unit. Since we have assumed it takes one unit of raw material to produce one unit of the final good, the tariff depends directly on the volume of domestic production by firm 2. The total tariff proceeds will equal $r_3 PM_{32} M_{32}$ or $r_3 PM_{32} X_2$. One would expect, a priori, that the corporation will reduce produc-

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7 If PM_{32} were a choice variable of the multinational corporation, setting it equal to zero would make equation (4) identical to equation (1). All allocation and trade-flow effects within the MNE would then result from the initial change in the costs of the division that pays the ad valorem tax.

8 This condition assumes the transfer price set by the MNE is not affected by changes in corporate output or sales. However, many transfer prices are affected by these changes. For example, the MNE may price according to 'fair market value' in the country of origin, which, in this case, is approximately equal to the price at which the output of firm 1 is sold to its domestic customers, P_1, or average cost prices may be used. The appendices include these 'variable transfer pricing' cases. For a detailed explanation of variable transfer pricing see Eden (1976).

tion in firm 2 and substitute imports from firm 1, or under-invoice imports from firm 3 in order to minimize tariff costs.[9] The new first-order condition is

$$MR_1 = MC_1 + MC_3 = MR_2 = MC_2 + MC_3 + r_2 PM_{32}. \tag{5}$$

The tariff is an import tariff by country 2 on unfinished goods shipped from firm 3 to firm 2. Production costs of firm 2 are increased by the tariff, and as a result the firm's derived demand for the primary good is reduced. The tariff will therefore indirectly affect primary production costs. Since firm 3 faces rising costs, the decline in its sales to firm 2 will cause primary production costs to fall, causing second-order effects throughout the system.

Since, by assumption, $X_3 = Y_3 = X_1 + X_2 = Y_1 + Y_2$, a fall in firm 3's total sales and output implies less will be sold domestically by both secondary divisions together. Hence a tariff on firm 2's primary imports adversely affects not only consumers of its own product but also consumers of firm 1's product. Furthermore, the primary tariff acts as a wedge between the marginal costs of the secondary firms, causing production to expand in firm 1 and contract in firm 2. Since domestic sales decrease and domestic output increases for firm 1 (the low-cost low-revenue firm), intrafirm secondary trade flows will expand.

In summary, the effects on corporate behaviour will differ depending on whether the tariff applies to finished goods (firm 1's exports) or to intermediate goods (firm 3's exports). Both tariffs cause a decline in total output and sales. With a tariff on firm 2's imports from firm 1 the goal of the MNE (if money transfer prices cannot be manipulated) is to minimize tariff costs by reducing secondary exports and substituting local production in country 2. When the tariff applies to intermediate goods, however, the corporation substitutes increased exports from the other secondary firm. A tariff on secondary imports raises prices and reduces sales in the importing country while lowering prices and increasing sales in the exporting country. A tariff on primary imports, however, harms consumers in countries 2 and 3. Since the government of country 1 does not receive any of the tariff revenue, the consumer loss is not partially offset by the government gain, as is the case in country 2.

Tariffs on both primary and secondary imports

If the government of country 2 levies tariffs on both final and intermediate imports, the effects will depend on the relevant tariff rates and money transfer prices. Assuming the government regulates money transfer prices, the MNE will be forced to adjust trade flows in order to minimize its tariff burden. Primary trade flows will definitely contract, but secondary trade flows could expand or contract depending upon the relative strengths of the primary and secondary tariff effects. The first-order condition (assuming firm 1 is the initial exporter of the secondary good) is

$$MR_1 + r_1 PM_{12} = MC_1 + r_1 PM_{12} + MC_3 = MR_2 = MC_2 + r_3 PM_{23} + MC_3. \tag{6}$$

9 Horst (1972) notes that exports to a Canadian subsidiary by a US parent corporation are a substitute for direct sales by the subsidiary in Canada. The higher the Canadian tariff, the smaller the share of US exports in total MNE sales to the Canadian market.

The tariff on secondary trade drives a wedge between the marginal revenues of the two secondary firms. The tariff on primary imports will tend to offset this as far as secondary processing is concerned (see equations A.7 and A.8). The tariff on secondary imports discourages secondary trade, while the tariff on primary imports encourages it.[10] Hence, it is possible that firm 1's exports to firm 2 may be unaffected. This is because the contraction of primary output causes marginal primary costs to decline, lowering the shadow price of primary imports to firm 1. Thus firm 1 can reduce its processing costs and keep up its exports to firm 2. As a result, country 2's tariffs on primary and secondary imports end up hurting its own secondary industry, leaving firm 1 unscathed.

THE VERTICAL MODEL UNDER PROFIT TAXATION

Taxation by the home country only

Assume initially that only the home government levies a tax on economic profits. While unrealistic, this assumption simplifies the analysis without greatly affecting the conclusions.

Assume the multinational enterprise consists of a parent firm, firm 1, and two affiliates, firms 2 and 3, and that country 1 levies a tax on pure profits. Under simplified source rules country 1 cannot tax the profits of firms 2 and 3 since they are earned outside its borders. Under simplified residence rules global income is taxable according to place of incorporation or seat of management. If the affiliate firms are branches of the MNE, their place of residency is country 1 and their profits are fully taxable as earned by the government of country 1. If, however, they are subsidiaries of the MNE, common practice is to defer tax payments until the foreign profits are remitted as dividends to firm 1.

Let t_1 be the tax rate levied by country 1 on the pure profits of firms resident within its borders. Let b_2 represent the fraction of firm 2's profits legally taxable in country 1. If b_2 equals zero, source rules apply, so that none of firm 2's profits are taxable whether remitted to country 1 or not. If b_2 equals one, residence rules are being followed and firm 2 is a branch of the MNE, so that all of its profits are taxed as earned. Where b_2 lies between zero and one, residence-subsidiary rules apply, so that remitted dividends are taxable in country 1. In this range b_2 ceases to be a parameter and becomes a decision variable for the MNE. Similarly, let b_3 represent the fraction of firm 3's profits legally taxable in country 1.

Under source rules only firm 1's profits are taxed and a priori one would assume the goal of the corporation would therefore be to shift profits to firms 2 and 3 where they face no tax. This can be accomplished by setting a high transfer price for firm 1's raw material imports from firm 3 and a low transfer

10 This assumes firm 2 is the high cost-high revenue firm before trade. If it were the low-cost, low-revenue firm it would be exporting the secondary good to firm 1 instead of importing it. If firm 2's government then levies tariffs on primary and secondary imports, only the primary tariff would directly affect firm 2 raising its processing costs and causing its output and sales to fall. Since firm 1's domestic sales would contract and output expand, secondary trade flows would contract.

price for firm 1's exports to firm 2, assuming that revenue-cost conditions are such that trade flows from firm 1 to firm 2. (If secondary trade initially flows from firm 2 to firm 1, the MNE could set a high money transfer price on these flows to reduce firm 1's accounting profits for tax purposes.) The scope for tax avoidance will be greatest under source rules.

Under residence rules the form of organization of the affiliates affects the total tax bill. If both affiliates are branches, all three firms are taxed at the same rate on earned profits, so that transfer price manipulations will not affect the total tax bill. Where both affiliates are subsidiaries of the MNE, foreign profits are taxed only when remitted to the parent, while retained earnings face no tax (unless the other countries have corporation income taxes, which they normally do). Here manipulating transfer prices and rates of dividend repatriation can lower the amount of tax paid to country 1. Where one firm is a branch and the other a subsidiary, the corporation will attempt to shift profits to the subsidiary to minimize its tax burden. If firm 3 is the subsidiary, the MNE will set high money transfer prices on exports to firms 1 and 2, whereas if firm 2 is the subsidiary, exports from firms 1 and 3 will carry low transfer prices.

If the MNE cannot alter its money transfer prices (perhaps because the government has imposed restrictions on them) altering dividend payments can be used to minimize tax payments. The lower the remittance rate of dividends to the parent firm, the lower the total tax bill paid by the multinational. Just as different money transfer prices can affect intrafirm trade flows, so also do different repatriation rates. This can be seen from the first-order conditions in appendix B (assuming money transfer prices are fixed and the parent firm initially exports the secondary good):

$$(1 - t_1)MR_1 + (t_1 - b_2 t_1)PM_{12} = (1 - t_1)MC_1 + (t_1 - b_2 t_1)PM_{12}$$
$$- (t_1 - b_3 t_1)PM_{31} + (1 - b_3 t_1)MC_3 = (1 - b_2 t_1)MR_2$$
$$= (1 - b_2 t_1)MC_2 - (b_2 t_1 - b_3 t_1)PM_{32} + (1 - b_3 t_1)MC_3. \quad (7)$$

The effects of the profits tax can be broken down into four sets. First, as long as the legal rate of repatriation is less than one, the tax has trade-expanding effects by reducing processing costs for the exporter and reducing the attractiveness of domestic sales in comparison to exports. Let us call these the ad valorem secondary tax effects. They imply there is an incentive to increase trade in order to shift profits abroad where these profits face a lower tax rate. Second, the higher the money transfer price of these exports, the greater the share of profits allocated to the exporter. Let us call these the specific secondary tax effects, since the higher the net per-unit tax on secondary trade, the more these effects tend to discourage trade. Depending on the money transfer price either the ad valorem or the specific effects could dominate. Secondary trade expands if the ad valorem effects dominate and contracts if the specific effects are stronger.

The third set of effects can be called the ad valorem primary tax effects since they affect the marginal cost of primary production and thus can alter primary

$b_3 > b_2$

output and trade flows. If the legal repatriation rate is higher for firm 3 than for firm 2, MC_3 shifts down, having a trade-expanding effect. By expanding primary sales the MNE is able to shift trade profits to the importing firms. On the other hand, if b_2 exceeds b_3, the ad valorem primary effects are trade-contracting. The fourth set of effects, the specific primary tax effects, work against the ad valorem primary effects and may outweigh them if the money transfer price is high enough. These effects can be subdivided depending on whether trade between firms 1 and 3 or between firms 2 and 3 is altered. Let us look at the effect on M_{32} first. If b_3 exceeds b_2, then MC_2 shifts up by the net tax on PM_{32}, implying that a high transfer price allocates most profits to firm 3 (which faces the higher tax rate). This tends to discourage primary exports. If b_2 exceeds b_3, firm 2 will be encouraged to import more of the primary good in order to reduce the total tax bill. The tax also alters M_{31} flows. If the parent firm has a higher tax than firm 3, then regardless of the relationship between b_2 and b_3 the specific primary tax effects will work to increase the parent firm's primary imports. The specific primary tax effects can also alter the allocation of secondary output since they drive a wedge between the marginal costs of the secondary firms. Depending on the size of the transfer prices PM_{31} and PM_{32} and on remittance rates, production may be shifted from one division to the other.

The net effect on the multinational will depend on the differing money transfer prices and methods of dividend payment. Intrafirm trade flows will expand or contract depending on the relative strengths of the ad valorem and specific effects.

Perhaps it may be useful to examine more closely the only case where a profits tax on a multiplant multimarket monopolist, such as the multinational enterprise in this article, actually falls wholly on corporation profits and is not shifted forward to consumers or backward to factor owners. This is the case where the home country follows residence rules and all the foreign affiliates are branches. In this case all corporate profits, wherever earned, are taxed at the rate t_1 so the MNE cannot avoid taxes by shifting the location of profit declaration. The conditions for profit maximization as a result are identical to conditions (1), (2), and (3). Money transfer price manipulations have no role to play in determining total output or sales of the coroporation nor the total tax bill paid by the MNE in country 1. The tax incidence falls wholly on corporation profits.

It is interesting to compare these results with those derived from Copithorne's 1971 model on taxation of vertically integrated multinationals, which, although set up quite differently, also concludes that taxes are not shifted by the multinational enterprise. The MNE in that model faces continuous progressive tax rates in each country. By equalizing the marginal tax rates levied on the pure profits of the foreign subsidiaries, Copithorne concludes that the global tax bill is minimized and no changes in output or prices occur. The total tax incidence falls on the MNE. From this he moves to the case of fixed tax rates and concludes that the enterprise should manipulate transfer prices so as to

shift profits to the subsidiary with the lowest tax rate. However, he feels this does not alter the conclusion that no changes in output or prices occur. In this article we have shown that only in the peculiar case where all foreign affiliates are organized as branches and the home government taxes on the basis of residence rules will the corporation pay the full tax and not adjust its output or sales. In general, taxes will be shifted by the multinational enterprise by adjusting money transfer prices, repatriation rates, and/or trade flows. The difference in our models occurs in our assumptions regarding money transfer prices. In the model presented here transfer prices are at least partly fixed because of government regulations. In Copithorne's model, money transfer prices are decision variables that can be chosen at will. Therefore prices could be chosen such that the pure profits tax would have no effect on total output even where both affiliates were organized in subsidiary form.

Taxation by home and host countries

If we allow for the more realistic case that both home and host governments levy profits taxes, we must expand the model to include possible responses by the home government in calculating the tax payable by foreign affiliates of the home firm. I assume three possible responses. First, the home government ignores the foreign tax in calculating its taxes levied on the affiliates. As a result part of firm 2 and firm 3's profits ($b_2\pi_2$ and $b_3\pi_3$) will be taxed twice, once at the host country's rate and again at the home tax rate. Second, the home government permits the deduction of foreign taxes in computing the extra tax payable. Firm 2 then pays $t_2\pi_2$ to its government and $t_1b_2(1 - t_2)\pi_2$ to country 1. Similarly, firm 3 pays $[t_3 + t_1b_3(1 - t_3)]\pi_3$ in taxes. Unless zero profits are repatriated, some double taxation of foreign profits will remain. Third, the home government allows full credit for foreign taxes in computing its tax bill. As long as the full credit is permitted (usually not past the point where the foreign tax rate exceeds the home rate) double taxation is removed. These three forms of tax relief are represented by the variable a_i, which is the form of tax relief provided by the home government in determining firm i's tax bill.

As equations (B. 22), (B. 23), and (B. 24) show, the profit-maximization conditions are complicated. However, (assuming fixed money transfer prices) they can still be broken into the four sets of effects outlined in the previous section, the ad valorem and specific secondary tax effects and the ad valorem and specific primary tax effects. If the home firm has a higher net tax rate than the foreign affiliates, the analysis above continues to apply. If the foreign firms have higher rates, the effects are in the opposite direction.

CONCLUSIONS

The model presented here could obviously be expanded to include other interesting problems, such as the way taxes plus tariffs affect corporate behaviour. However, the basic results of the analysis are clear. Where money transfer prices are constrained by government regulation, total corporate output and

sales and their allocation between the secondary divisions will be affected by tariffs and international tax differentials. By affecting cost and revenue functions, money transfer prices do alter the shadow prices of primary and secondary exports. The tariff and tax effects on trade flows can be subdivided into specific and ad valorem primary and secondary effects, and the result can be predicted depending on the size of the money transfer prices, tax or tariff rates, and dividend remittance practices.

APPENDIX A: PROFIT MAXIMIZATION WHEN COUNTRY 2 LEVIES IMPORT TARIFFS

$$\pi_1 = P_1 Y_1 - C_1 - \text{PM}_{21} M_{21} + \text{PM}_{12} M_{12} - \text{PM}_{32} M_{32}; \qquad (\text{A.1})$$
$$\pi_2 = P_2 Y_2 - C_2 + \text{PM}_{21} M_{21} - (1 + r_1)\text{PM}_{12} M_{12} - (1 + r_3)\text{PM}_{32} M_{32}; \quad (\text{A.2})$$
$$\pi_3 = \text{PM}_{31} M_{31} + \text{PM}_{32} M_{32} - C_3; \qquad (\text{A.3})$$

where

X_i is the level of processing in firm i, $i = 1, 2, 3$;
Y_i is the level of domestic sales to consumers by firm i, $i = 1, 2$;
M_{ij} is the volume of firm i's exports to firm j, $i, j = 1, 2, 3, i \neq j$;
$M_{12} = X_1 - Y_1$;
$M_{21} = X_2 - Y_2$;
$M_{21} + M_{12} = 0$;
$M_{31} + M_{32} = X_3 = Y_3$;
$X_1 + X_2 = Y_1 + Y_2 = X_3 = Y_3$;
$P_i Y_i$ is the value of firm i's domestic sales, $P_i = f(Y_i)$, $dP_i/dY_i < 0$, $i = 1, 2, 3$;
C_i is firm i's total production costs, $C_i = f(X_i)$, $dC_i/dX_i > 0$, $i = 1, 2, 3$;
$\text{PM}_{ij} M_{ij}$ is the value of firm i's exports to firm j, $d\text{PM}_{ij}/dM_{ij} \lessgtr 0$, $i, j = 1, 2, 3, i \neq j$;
r_i is the ad valorem tariff levied on firm i's exports to firm 2, $i = 1, 3$;
π_i is the economic profit earned by firm i, $i = 1, 2, 3$.

The Lagrangian expression[11] to be maximized is

$$
\begin{aligned}
L_\pi = {} & P_1 Y_1 - C_1 + P_2 Y_2 - C_2 - C_3 - r_1 \text{PM}_{12} M_{12} - r_3 \text{PM}_{32} M_{32} \\
& + \lambda_1 (X_3 - X_1 - X_2) + \lambda_2 (X_3 - Y_1 - Y_2) + \lambda_3 (M_{12} - X_1 + Y_1) \\
& + \lambda_4 (M_{32} - X_2), \quad (\text{A.4})
\end{aligned}
$$

from which the first-order conditions are

$$\partial L/\partial Y_1 = \text{MR}_1 - \lambda_2 + \lambda_3 = 0; \qquad (\text{A.5})$$
$$\partial L/\partial Y_2 = \text{MR}_2 - \lambda_2 = 0; \qquad (\text{A.6})$$
$$\partial L/\partial X_1 = -\text{MC}_1 - \lambda_1 - \lambda_3 = 0; \qquad (\text{A.7})$$
$$\partial L/\partial X_2 = -\text{MC}_2 - \lambda_1 - \lambda_4 = 0; \qquad (\text{A.8})$$

11 Note that, if it were not for the tariffs, the money transfer prices PM₁₂ and PM₃₂ would drop out of the expression altogether. This is the case illustrated in the second section of the paper; PM₂₁ has dropped out of the expression because the secondary tariff only applies to trade flows in one direction – from firm 1 to firm 2.

$$\partial L/\partial X_3 = MC_3 + \lambda_1 + \lambda_2 = 0; \tag{A.9}$$

$$\partial L/\partial M_{12} = -r_1 PM_{12} - r_1 M_{12}\, dPM_{12}/dM_{12} + \lambda_3 = 0; \tag{A.10}$$

$$\partial L/\partial M_{32} = -r_3 PM_{32} - r_3 M_{32}\, dPM_{32}/dM_{32} + \lambda_4 = 0; \tag{A.11}$$

$$\partial L/\partial \lambda_1 \cdot = X_3 - X_1 - X_2 = 0; \tag{A.12}$$

$$\partial L/\partial \lambda_2 = X_3 - Y_1 - Y_2 = 0; \tag{A.13}$$

$$\partial L/\partial \lambda_3 = M_{12} - X_1 + Y_1 = 0; \tag{A.14}$$

$$\partial L/\partial \lambda_4 = M_{32} - X_2 = 0; \tag{A.15}$$

which can be rewritten as

$$MR_1 + \lambda_3 = MR_2; \tag{A.16}$$

$$MC_1 + \lambda_3 + MC_3 = MC_2 + \lambda_4 + MC_3; \tag{A.17}$$

$$MR_1 + \lambda_3 = MC_1 + \lambda_3 + MC_3 = MR_2 = MC_2 + \lambda_4 + MC_3. \tag{A.18}$$

The third and fourth Lagrangian multipliers (equations A.10 and A.11) are the per-unit tariffs on firm 2's imports. Where money transfer prices are fixed and do not vary with the volume of intrafirm trade the tariff costs are also fixed. Equations (A.18) are the conditions for determining total corporate output, while equations (A.16) allocate total secondary sales and (A.17), total secondary output. In the absence of tariffs, equations (A.16), (A.17), and (A.18) reduce to

$$MR_1 = MC_1 + MC_3 = MR_2 = MC_2 + MC_3 \tag{A.19}$$

APPENDIX B: PROFIT MAXIMIZATION UNDER PROFITS TAXATION

$$\pi_1 = (1 - t_1)[P_1 Y_1 - C_1 - PM_{21}M_{21} + PM_{12}M_{12} - PM_{31}M_{31}]; \tag{B.1}$$

$$\pi_2 = (1 - t_2 - b_2 t_1 + a_2)[P_2 Y_2 - C_2 + PM_{21}M_{21} - PM_{12}M_{12} - PM_{32}M_{32}]; \tag{B.2}$$

$$\pi_3 = (1 - t_3 - b_3 t_1 + a_3)[PM_{31}M_{31} + PM_{32}M_{32} - C_3], \tag{B.3}$$

where t_i is the tax rate levied by government i, $i = 1, 2, 3$, $0 \leqslant t_i \leqslant 1$; b_i is the fraction of firm i's profits legally taxable by the home country (assumed to be country 1) $i = 2, 3$, $0 \leqslant b_i \leqslant 1$; a_i is the form of tax relief provided by the home country in determining firm i's tax bill, $i = 2, 3$, $0 \leqslant a_i \leqslant 1$. Where $a_i = 0$, no tax relief is given; where $a_i = b_i t_1 t_i$, foreign taxes are deductible in determining firm i's tax payment to country 1; and where $a_i = b_i t_i$, foreign taxes are creditable against the taxes owed by firm i to country 1.

The Lagrangian expression to be maximized is

$$\begin{aligned}
L_\pi = {} & (1 - t_1)[P_1 Y_1 - C_1] + (1 - t_2 - b_2 t_1 + a_2)[P_2 Y_2 - C_2] \\
& - (1 - t_3 - b_3 t_1 + a_3)C_3 + (t_1 - t_2 - b_2 t_1 + a_2)PM_{21}M_{21} \\
& - (t_1 - t_2 - b_2 t_1 + a_2)PM_{12}M_{12} + (t_1 - t_3 - b_3 t_1 + a_3)PM_{31}M_{31} \\
& + (t_2 - t_3 + b_2 t_1 - b_3 t_1 + a_3 - a_2)PM_{32}M_{32} + \lambda_1(X_3 - X_1 - X_2) \\
& + \lambda_2(X_3 - Y_1 - Y_2) + \lambda_3(M_{12} - X_1 - Y_1) + \lambda_4(M_{21} - X_2 + Y_2) \\
& + \lambda_5(M_{31} - X_1) + \lambda_6(M_{32} - X_2); \quad (A.4); \quad (B.4)
\end{aligned}$$

$$\partial L/\partial Y_1 = (1 - t_1)\mathrm{MR}_1 - \lambda_2 + \lambda_3 = 0; \tag{B.5}$$

$$\partial L/\partial Y_2 = (1 - t_2 - b_2 t_1 + a_2)\mathrm{MR}_2 - \lambda_2 + \lambda_4 = 0; \tag{B.6}$$

$$\partial L/\partial X_1 = -(1 - t_1)\mathrm{MC}_1 - \lambda_1 - \lambda_3 - \lambda_5 = 0; \tag{B.7}$$

$$\partial L/\partial X_2 = -(1 - t_2 - b_2 t_1 + a_2)\mathrm{MC}_2 - \lambda_1 - \lambda_4 - \lambda_6 = 0; \tag{B.8}$$

$$\partial L/\partial X_3 = -(1 - t_3 - b_2 t_1 + a_3)\mathrm{MC}_3 + \lambda_1 + \lambda_2 = 0; \tag{B.9}$$

$$\partial L/\partial M_{21} = (t_1 - t_2 - b_2 t_1 + a_2)\mathrm{PM}_{21} + (t_1 - t_2 - b_2 t_1 + a_2)$$
$$\times M_{21} \cdot d\mathrm{PM}_{21}/dM_{21} + \lambda_4 = 0; \tag{B.10}$$

$$\partial L/\partial M_{12} = -(t_1 - t_2 - b_2 t_1 + a_2)\mathrm{PM}_{12} - (t_1 - t_2 - b_2 t_1 + a_2)$$
$$\times M_{12} \cdot d\mathrm{PM}_{12}/dM_{12} + \lambda_3 = 0; \tag{B.11}$$

$$\partial L/\partial M_{31} = (t_1 - t_3 - b_3 t_1 + a_3)\mathrm{PM}_{31} + (t_1 - t_3 - b_3 t_1 + a_3)$$
$$\times M_{31} \cdot d\mathrm{PM}_{31}/dM_{31} + \lambda_5 = 0; \tag{B.12}$$

$$\partial L/\partial M_{32} = (t_2 - t_3 + b_2 t_1 - b_3 t_1 + a_3 - a_2)\mathrm{PM}_{32}$$
$$+ (t_2 - t_3 + b_2 t_1 - b_3 t_1 + a_3 - a_2)M_{32} d\mathrm{PM}_{32}/dM_{32} + \lambda_6 = 0; \tag{B.13}$$

$$\partial L/\partial b_2 = -t_1 P_2 Y_2 + t_1 C_2 - t_1 \mathrm{PM}_{21} M_{21} + t_1 \mathrm{PM}_{12} M_{12} + t_1 \mathrm{PM}_{32} M_{32}$$
$$= 0; \tag{B.14}$$

$$\partial L/\partial b_3 = t_1 C_3 - t_1 \mathrm{PM}_{31} M_{31} - t_1 \mathrm{PM}_{32} M_{32} = 0; \tag{B.15}$$

(provided, in (A.14) and (A.15), the repatriation rate is a decision variable for the corporation)

$$\partial L/\partial \lambda_1 = X_3 - X_1 - X_2 = 0; \tag{B.16}$$

$$\partial L/\partial \lambda_2 = X_3 - Y_1 - Y_2 = 0; \tag{B.17}$$

$$\partial L/\partial \lambda_3 = M_{12} - X_1 + Y_2 = 0; \tag{B.15}$$

$$\partial L/\partial \lambda_4 = M_{21} - X_2 + Y_2 = 0; \tag{B.19}$$

$$\partial L/\partial \lambda_5 = M_{31} - X_1 = 0; \tag{B.20}$$

$$\partial L/\partial \lambda_6 = M_{32} - X_2 = 0; \tag{B.21}$$

which can be rewritten as

$$(1 - t_1)\mathrm{MR}_1 + \lambda_3 = (1 - t_2 - b_2 t_1 + a_2)\mathrm{MR}_2 + \lambda_4; \tag{B.22}$$

$$(1 - t_1)\mathrm{MC}_1 + \lambda_3 + \lambda_5 + (1 - t_3 - b_3 t_1 + a_3)\mathrm{MC}_3 =$$
$$(1 - t_2 - b_2 t_1 + a_2)\mathrm{MC}_2 + \lambda_4 + \lambda_6 + (1 - t_3 - b_3 t_1 + a_3)\mathrm{MC}_3; \tag{B.23}$$

$$(1 - t_1)\mathrm{MR}_1 + \lambda_3 = (1 - t_1)\mathrm{MC}_1 + \lambda_3 + \lambda_5 + (1 - t_3 - b_3 t_1 + a_3)\mathrm{MC}_3$$
$$= (1 - t_2 - b_2 t_1 + a_2)\mathrm{MR}_2 + \lambda_4$$
$$= (1 - t_2 - b_2 t_1 - a_2)\mathrm{MC}_2 + \lambda_4 + \lambda_6$$
$$+ (1 - t_3 - b_3 t_1 + a_3)\mathrm{MC}_3. \tag{B.24}$$

The third and fourth Lagangian multipliers are the per unit net taxes on secondary trade flows, while the fifth and sixth multipliers represent the net

taxes on primary trade flows. Since corporate profits taxes apply to secondary trade in both directions, the objective expression contains terms for both M_{12} and M_{21}. In equilibrium the secondary firms will not normally sell the same product back and forth between each other, so one of these terms will disappear. This is in contrast to the expression where tariffs are present and terms containing M_{21} disappear.

Where transfer prices do not vary with intrafirm trade, the Lagrangian multipliers reduce to simple fixed tax costs.

If the multinational enterprise can choose its dividend remittance rates, equations (B.14) and (B.15) suggest that the MNE allocate its profits so that no taxes are payable in the home country by firms 2 and 3.

Equations (B.24) are the conditions for determining total MNE output, while (B.22) allocates secondary sales and (B.23) allocates secondary output.

If only the home government levies a profits tax, the conditions for profit maximization reduce to

$$(1 - t_1)\text{MR}_1 + \lambda_3 = (1 - b_2 t_1)\text{MR}_2 + \lambda_4; \tag{B.25}$$

$$(1 - t_1)\text{MC}_1 + \lambda_3 + \lambda_5 + (1 - b_3 t_1)\text{MC}_3 = (1 - b_2 t_1)\text{MC}_2 + \lambda_4 + \lambda_5 \\ + (1 - b_3 t_1)\text{MC}_3; \tag{B.26}$$

$$(1 - t_1)\text{MR}_1 + \lambda_3 = (1 - t_1)\text{MC}_1 + \lambda_3 + \lambda_5 + (1 - b_3 t_1)\text{MC}_3$$
$$(1 - b_2 t_1)\text{MR}_2 + \lambda_4 = (1 - b_2 t_1)\text{MC}_2 + \lambda_4 + \lambda_6 + (1 - b_3 t_1)\text{MC}_3; \tag{B.27}$$

where

$$\lambda_3 = (t_1 - b_2 t_1)\text{PM}_{12} + (t_1 - b_2 t_1)M_{12} \cdot d\text{PM}_{12}/dM_{12};$$
$$\lambda_4 = -(t_1 - b_2 t_1)\text{PM}_{21} - (t_1 - b_2 t_1)M_{21} \cdot d\text{PM}_{21}/dM_{21};$$
$$\lambda_5 = -(t_1 - b_3 t_1)\text{PM}_{21} - (t_1 - b_3 t_1)M_{31} \cdot d\text{PM}_{31}/dM_{31};$$
$$\lambda_6 = -(b_2 t_1 - b_3 t_1)\text{PM}_{32} - (b_2 t_1 - b_3 t_1)M_{32} \cdot \text{DPM}_{23}/dM_{32}.$$

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