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Direct Investment and Trade:
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I. Introduction

The multinational corporation (MNC) has the choice of supplying foreign markets via either exports from the home market (US) or local production by a foreign subsidiary (FS). If the final (as distinguished from intermediate) U.S.-made and FS-produced goods are not identical the firm may do both. Two important questions in the analysis of the balance of payments impact of direct investment then arise. What determines this choice? And what is the impact of an increase in sales of the FS-product on sales of MNC exports? The purpose of this paper is to investigate these issues and especially the latter, the question of export displacement.

To date, the export displacement phenomenon has largely escaped theoretical or empirical analysis. The major exception is Hufbauer and Adler's (H-A) [12] analysis of the balance of payments consequences of U.S. direct private investment overseas. Depending on their interest, most observers have tended to assert either that F.S. sales compete very little with U.S. exports or that they fully displace them.[1] The assertion of these opposite points of view has frequently been grounded in two sets of assumptions which too frequently have been confused. On the one hand, minimizers of the export displacement effect seem to have argued that U.S. exports and the goods produced by F.S. are non-substitutes or complements in demand, while their opponents have supposed the goods to be perfect substitutes. These product-substitutability assumptions should be kept distinct from the implicit presumptions made by the opposing sides, on the other hand, regarding a different question: What would have happened to U.S. exports in the absence of F.S. production, i.e. what is the "alternative position?" Typically those who dismiss the export displacement effect as insignificant do so in conjuction with the assumption that in the FS's absence its goods would have been produced and sold by some other native or third-country firm. That is, they adopt what H-A called the "reverse classical" alternative position in which any increase in F.S. sales displaces only native-firm sales and has no effect on imports at all. Those who emphasize the importance of export-displacement, however, implicitly adopt H-A's classical hypothesis in which native firms do not supplant F.S. sales. In this case, increases in F.S. sales impact exclusively against imports. In short the debate over export-displacement has largely taken place within the framework of H-A's extreme assumptions and in the absence of any attempt except by conflicting assertion to determine which, or whether some mixture, of the assumptions as to product substitutability or the alternative position is better suited to empirical fact.[2]

Our paper grapples with and attempts to resolve some of these questions theoretically and empirically in the context of a two tier micro-theoretical model of market conditions abroad, as set forth in section II and the appendix. The first tier is a model of a global-profit-maximizing MNC which produces two non-identical, partially substitutable products, one in the U.S. for home consumption and export and one abroad, for foreign consumption only. The second tier is added by nesting the MNC model in a model of the foreign market, in which the MNC's two products compete with, and partially or perfectly substitute for, goods produced for local consumption by native firms and products imported from third countries. There are several innovations in this partial-equilibrium approach from which subsequent benefits emerge.

Section II, which lays out the full model structure, introduces a precise and flexible definition of the export displacement effect. It is precise in the sense that it flows unambiguously from the comparative statics of the model and involves parameters which in principle can be measured empirically. It is flexible because it can be made to accommodate any number of competitors to the MNC, alternative assumptions with respect to product substitutability (the "associated export effect") and can if necessary be extended to include intermediate goods (the "parts and components effect"). When intermediates are ignored, our analysis suggests that neither the classical nor the reverse-classical hypothesis will accurately portray the alternative position against which the export displacement effect actually takes place.

Our assumptions with respect to product homogeneity and the inclusion of market behavior distinguish our model from Horst's [11] excellent treatment of the MNC taken in isolation. Horst assumed that his MNC exported and produced abroad identical products. In contrast, we assume, perhaps more realistically for the markets we consider below, that the MNC's exports and the goods produced by FS and native firms are non-identical, partial substitutes: their price cross-elasticities may be large but need not be infinite.[3] There are several reasons for our different choice of setting.

First and most importantly, it is impossible fully to investigate export displacement in a model, such as Horst's, which excludes native firms. One can certainly analyse the trade-off between exporting and producing abroad in the single-firm context while ignoring other firms, as we do in Section II. But assuming identical goods, (Horst's case) is equivalent to the forced assumption, ab - initio of (a modification of) the classical position. In the absence of native firm or other products, increases in FS sales will necessarily reduce MNC exports of the same good exclusively. Even in Horst's model, the impact will not generally be one for one (the classical case). In our model, however, the effect can even disappear, as shown below.

Our model, on the other hand, incorporates a modified version of reverse classical behavior. Perfect classical behavior is excluded, for with native firms producing substitutes, U.S. exports will not alone bear the brunt of the displacement effect. Equally, perfect reverse classical behavior is unlikely, for in the presence of U.S. exports, increases in F.S. sales will not react exclusively against native firms. This consistent admixture of possibilities seems reasonable especially since the "classical" and "reverse classical" positions were chosen by H-A [12] in the first instance as polar extremes and not as representative of reality.

In the second place, it will be recalled that Horst's model produced interior solutions, with the MNC both producing in two locations and exporting, only when the sum of the slopes of the marginal cost functions was positive. Under the alternative assumptions of constant or decreasing costs, radically different patterns, emerged. These corner solutions involved either production in both places with no trade, or production in one with the second supplied exclusively by trade. Our model, however, provides interior solutions for the empirically relevant case of constant returns to scale. Nonetheless, the existence of interior solutions, the size of the export displacement effect and the impact of changes in other exogenous variables do depend critically on the equilibrium values and slopes of the underlying cost and demand functions. We therefore devote Section III to an empirical examination of the structure of the production functions and the consequent cost functions of U.S. foreign subsidiaries and native firms in the chemical and electrical engineering industries in Germany, Canada and Japan.

Section IV presents a preliminary empirical analysis of the export displacement effect and the effects on the MNC's optimum of changes in other key factors, such as the cost of capital and foreign tax and tariff rates, in the full, four-firm, three - good, market nexus. Our technique is to estimate the effects on the equilibrium outputs of each competitor caused by a small change in some underlying parameter. These comparative statics are calculated at the point which represents the 1966 equilibrium values of the variables in the model. Of course, rather than use the 1966 equilibrium values as the point of reference, one could alternatively solve for equilibrium for any given values of the exogenous parameters. However, this would require solving a set of simultaneous, non-linear equations and will not be attempted here. When the MNC is considered alone, it is relatively straightforward to assess the signs and sizes of the determinant of the relevant Hessian and all its principle minors. When the MNC is embedded in the broader setting, however, these signs and sizes generally remain ambiguous. Consequently, the 1966 equilibrium levels and the comparative statics at that point are calculated numerically. A concluding section summarizes, discusses caveats and suggests promising directions for future research.

II. The MNC in the Foreign Market

A. Model Structure

The objective of this section is to set forth the theoretical structure of our model of the MNC in the foreign market strictly in conformity with the empirical requirements of the data analyzed below. For these purposes it is sufficient to consider a static, one-period model of a MNC, with production and sales operations in two countries, involving the parent in country 1 (the U.S) and a subsidiary in country 2. The MNC behaves as a maximizer of its long-run profits from the sale of two differentiated products.[4] Good 1 is produced by the MNC in the U.S. in the amount Q_1 of which S_{11} is sold in the U.S. while S_{12} is exported to country 2: $Q_1 = S_{11} + S_{12}$. Good 2 is produced and sold by the F.S. in country 2: $Q_2 = S_{22}$.[5]

The two goods sold by the MNC in country 2 compete with two additional differentiated products: sales in the quantity S_{32} of goods produced by and imported from third country firms; and S_{42} of the products of native firms. Because price-data are not presently, or ever likely to be, available separately for U.S. subsidiaries and native firms, we are forced for empirical purposes to assume that S_{22} and S_{42} represent an identical good, the total sales of which are $S_{T2} = S_{22} + S_{42}$. In this case we assume that U.S. subsidiaries and native firms behave as Cournot-type imperfect competitors with respect to their common product; that is, they ignore the effects of their actions on the sales of their competitors. It is a small step from this convenient assumption to the general model of totally differentiated products, and in section IV alternative calculations are presented for both the general and Cournot cases.

The demand for each distinct product in the country 2 market is most easily estimated as a function of its own prices, the prices of competing goods and income. Letting the vector $\underline{P}_2 = (P_{12}, P_{T2}, P_{32})$, $S_{i2} = S_{i2}(\underline{P}_2, Y)$, $i = 1,\ldots,4$ where own price-elasticities are negative and price cross-elasticities are positive if the products are substitutes; all income elasticities are positive. For purposes of the theoretical development, however, the demand functions are more conveniently employed in their inverse form. Letting the vector $\underline{S}_2 = (S_{12}, S_{T2}, S_{32})$, $P_{i2} = P_{i2}(\underline{S}_2)$, where <u>all</u> partial derivatives will be negative if the several products are gross substitutes.[6] Sales revenues from product i in market 2 are therefore given by $R_{i2} = S_{i2}P_{i2}(\underline{S}_2) = R_{i2}(\underline{S}_2)$. For simplicity, we assume that U.S. sales of the MNC's good 1 depend on its own price alone: $S_{11} = S_{11}(P_{11})$ and, inverting, $P_{11} = P_{11}(S_{11})$. Similarly the home (i.e. country 3) market price of the goods produced by third-country firms, $P_{33} = P_{33}(S_{33})$. We may now proceed to model the market system by writing the profit-maximands of the three firms which compete in the second market.

The MNC's after-tax net revenues ariseing in country 1 from selling good 1 are:

(1) $\left[S_{11} P_{11}(S_{11}) + \pi_1 S_{12} - C_1(S_{11} + S_{12}) \right] (1-t_1)$, where $C_1 = C_1(Q_I)$ is the cost function of good 1, Π_1 is the export transfer price of good 1 set by the MNC and t_1 is the tax rate in country 1. MNC (dollar) profits from selling good 1 in 2 are

(2) $\left[S_{12} P_{12} (\underline{S}_2) - (1 + \tau_2) \frac{\pi_1}{f_1} S_{12} \right] (1-t_2)f_1$, where τ_2 and t_2 are country 2's tariff and tax rates, respectively, and f_1 is the exchange rate between 1 and 2.

The MNC also profits from selling good 2 in 2:

$$(3)\quad \left[S_{22}P_{22}(\underline{S}_2) - C_2(S_{22}) \right](1-t_2)f_1$$

Summing expressions (1)-(3), total MNC profits may be rewritten as

$$(4)\left[R_{11}(S_{11}) - C_1(S_{11} + S_{12})\right](1-t_1) + \left[R_{22}(\underline{S}_2) - C_2(S_{22}) + R_{12}(\underline{S}_2)\right] (1-t_2)f_1-\pi_1T_1S_{12}$$

where $T_1 = \tau_2(1-t_2) - (t_2-t_1)$. This expression is similar in several respects to Horst's [11] and preserves his insight that the MNC will set π_1 as low as possible if $T_1 > 0$, i.e. if $\tau_2 > (t_2-t_1) / (1-t_2)$. Note that $R_{22} = S_{22}P_{T2}(\underline{S}_2)$

In a similar fashion, the objective function of the third country firm may be written as the sum of their after-tax profits from producing and selling their good 3 at home and from exporting it to country 2, as follows:

$$(5)\quad \left[R_{33}(S_{33}) - C_3(S_{33} + S_{32})\right] (1-t_3)+f_3(1-t_2) \left[R_{32}(\underline{S}_2)\right]- \pi_3T_3S_{32}$$

where $T_3 = \tau_2(1-t_2) - (t_2-t_3)$

Finally, the maximand of the native firms which for simplicity do no exporting may be written as:

$$(6)\quad \left[R_{42}(\underline{S}_2) - C_4(S_{42}) \right] (1-t_2)$$

where $R_{42} = S_{42}P_{T2}(\underline{S}_2)$ and the cost functions $C_4(Q_4)$ and $C_2(Q_2)$ differ.

The first order necessary conditions for market equilibrium are established when each firm maximizes its own objective function with respect to its own decision variables, while holding the other firms' decisions constant. Firms, that is, take no account of the effects of their actions on others. The commonality of this assumption to all firms is guaranteed by the previous assumption of Cournot behavior on the part of U.S. subsidiaries and native firms.

The MNC maximizes with respect to S_{11}, S_{12} and S_{22}, giving:

(7a) $(R'_{11} - C'_1)\ (1-t_1) = 0$

(7b) $f_1(1-t_2)\ (R'_{12} + \partial R_{22} / \partial S_{12}) - \pi_1 T_1 - (1-t_1)\ C'_1 = 0$

(7c) $f_1(1-t_2)\ (R'_{22} + \partial R_{12} / \partial S_{T2} - C'_2) = 0$

where $R'_{ij} = \partial R_{ij} / \partial S_{ij} = P_{ij} + S_{ij}\ \partial P_{ij} / \partial S_{ij} > 0$; $\partial R_{i2} / \partial S_{j2} = S_{j2}\ \partial P_{i2} / \partial S_{j2} < 0$, $i \neq j$. Note that $\partial C_1 / \partial S_{1j} = dC_1 / dQ_1$ since $\partial Q_1 / \partial S_{1j} = 1$, $j=1,2$ and that $\partial R_{i2} / \partial S_{22} = \partial R_{i2} / \partial S_{T2}$ since $\partial S_{T2} / \partial S_{22} = 1$, $i=1,2$.

Similarly, third-country exporters maximize with respect to S_{33} and S_{32}:

(8a) $(R'_{33} - C'_3)\ (1-t_3) = 0$

(8b) $f_3(1-t_2)R'_{32} - (1-t_3)C'_3 - \pi_3 T_3 = 0$

Finally, native firms maximize with respect to S_{42}:

(9) $(R'_{42} - C'_4)\ (1-t_2) = 0$

where $R'_{42} = P_{T2} + S_{42}\ \partial P_{T2} / \partial S_{T2}$ since $\partial S_{T2} / \partial S_{42} = 1$.[7]

The simultaneous solution of the six equations in (7), (8) and (9) produces the point of market equilibrium. The simultaneity arises from the presence of interactive terms produced by the dependence of the demand function for each good on the quantities sold of the other goods. This equilibrium is clearly much more complex than Horst's [11] case which is somewhat similar to the three equations in (7) but without the cross-derivative terms owing to his assumption that S_{12} and S_{22} represent identical products.

The market will reach equilibrium if each firm is in equilibrium. It is therefore required, and we assume, that each firm's second-order, Hessian matrix is negative definite. The set of partial derivatives of each firm's first order conditions with respect to its own and the other firms' decision variables produces the 6x6 matrix of second-order conditions for market equilibrium set forth in Table 1. Note that the matrix is assymetric and is not a Hessian. The Hessians for each of the competitors are outlined diagonally. The restriction that these diagonal blocks are negative-definite is not, however, sufficient unambiguously to determine the sign, let alone the size of the determinant of the market-matrix.[8] In the actual event, it is therefore necessary to estimate its components empirically and to evaluate numerically the relevant comparative statics around the 1966 equilibrium, as we do in Section IV.

B. Export Displacement

As noted in the introduction, two sets of arguments have been adduced to provide a basis for the existence of the export displacement effect. One is rooted in the perfect, partial or non-substitutability of the goods produced at home and abroad by the MNC and its FS, ignoring foreign market conditions. The second set involves hypotheses relating both to the degree of substitutability between the kinds of products sold, on the one hand, by native firms and those produced by the MNC and its affiliates,

Table 1 **Second Order Matrix for the Market**

	dS_{11}	dS_{12}	dS_{22}	dS_{33}	dS_{32}	dS_{42}
dS_{11}	$(R''_{11}-C''_1)(1-t_2)$	$-(1-t_1)C''_1$	0	0	0	0
dS_{12}	$-(1-t_1)C''_1$	$f_1(1-t_2)(R''_{12}+\frac{\partial^2 R_{22}}{\partial S_{12}^2})$ $-(1-t_1)C''_1$	$f_1(1-t_1)\left[\frac{\partial^2 R_{12}}{\partial S_{T2}\partial S_{12}} + \frac{\partial^2 R_{22}}{\partial S_{T2}\partial S_{12}}\right]$	0	$f_1(1-t_2)\left[\frac{\partial^2 R_{12}}{\partial S_{32}\partial S_{12}} + \frac{\partial^2 R_{22}}{\partial S_{32}\partial S_{12}}\right]$	$f_1(1-t_2)\left[\frac{\partial^2 R_{12}}{\partial S_{T2}\partial S_{12}} + \frac{\partial^2 R_{22}}{\partial S_{T2}\partial S_{12}}\right]$
dS_{22}	0	$f_1(1-t_2)\left[\frac{\partial^2 R_{12}}{\partial S_{12}\partial S_{T2}} + \frac{\partial^2 R_{22}}{\partial S_{12}\partial S_{T2}}\right]$	$f_1(1-t_2)\left[R''_{22}-C''_2 + \frac{\partial^2 R_{12}}{\partial S_{T2}^2}\right]$	0	$f_1(1-t_2)\left[\frac{\partial^2 R_{12}}{\partial S_{32}\partial S_{T2}} + \frac{\partial^2 R_{22}}{\partial S_{32}\partial S_{T2}}\right]$	$f_1(1-t_2)\left[R''_{22}-\frac{\partial P_{T2}}{\partial S_{T2}} + \frac{\partial^2 R_{12}}{\partial S_{T2}^2}\right]$
dS_{33}	0	0	0	$(1-t_3)(R''_{33}-C''_3)$	$-(1-t_3)C''_3$	0
dS_{32}	0	$f_3(1-t_2)\left[\frac{\partial^2 R_{32}}{\partial S_{12}\partial S_{32}}\right]$	$f_3(1-t_2)\left[\frac{\partial^2 R_{32}}{\partial S_{T2}\partial S_{32}}\right]$	$-(1-t_3)C''_3$	$f_3(1-t_2)R''_{32}$ $-(1-t_3)C''_3$	$f_3(1-t_2)\left[\frac{\partial^2 R_{32}}{\partial S_{T2}\partial S_{32}}\right]$
dS_{42}	0	$(1-t_2)\frac{\partial^2 R_{42}}{\partial S_{12}\partial S_{T2}}$	$(1-t_2)\left[R''_{42}-\frac{\partial P_{T2}}{\partial S_{T2}}\right]$	0	$(1-t_2)\frac{\partial^2 R_{42}}{\partial S_{32}\,\partial S_{T2}}$	$(1-t_2)(R''_{42}-C''_4)$

on the other; and to the market-behavioral reactions of native firms to changes in the decisions of U.S. subsidiaries. In principle, both sets of issues can be investigated in the framework of comparative static analysis. For illustrative purposes we shall focus initially on the first because of the analytical intractability of the assymmetric 6x6 matrix of market second-order conditions.

Consider, then, the symmetric, negative-definite second order matrix, M, for a MNC maximum, taken in isolation from the market as a whole.

	dS_{11}	dS_{12}	dS_{22}
dS_{11}	$(1-t_1)\ (R''_{11} - C''_1)$	$-\ (1-t_1)\ C''_1$	0
dS_{12}	$-\ (1-t_1)\ C''_1$	$f_1(1-t_2)(R''_{12} + \frac{\partial^2 R_{22}}{\partial S_{12}^2}$ $-(1-t_1)\ C''_1$	$f_1(1-t_2)(\frac{\partial^2 R_{12}}{\partial S_{T2} \partial S_{12}} + \frac{\partial^2 R_{22}}{\partial S_{T2} \partial S_{12}})$
dS_{22}	0	$f_1(1-t_2)(\frac{\partial^2 R_{12}}{\partial S_{12} \partial S_{T2}} + \frac{\partial^2 R_{22}}{\partial S_{12} \partial S_{T2}})$	$f_1(1-t_2)(R''_{22} + \frac{\partial^2 R_{12}}{\partial S_{T2}^2} - C''_2)$

Will increasing foreign sales displace U.S. exports? In other words, what is the MNC's trade-off between exporting and producing abroad? Intuitively, the answer should depend on the changes in the relevant marginal revenues and costs caused by shifting sales from one location to the other. Taking the context of balance of payments regulation let us examine the effect on S_{12} of relaxing a restriction that has had the effect of holding S_{22} to some constant level, $\bar{S}_{22}$, which is suboptimal for the MNC. We seek the sign of $dS_{12} \;/\; d\bar{S}_{22}$. The effect of the assumed constraint is to remove the third of the three first order equations in (7). The remaining relevant conditions are (7a) and (7b) which we differentiate totally with respect to $\bar{S}_{22}$, producing

(10)

$$\begin{bmatrix} (1-t_1)(R''_{11} - C''_1) & -(1-t_1)C''_1 \\ -(1-t_1)\, C''_1 & f_1(1-t_2)(R''_{12} + \dfrac{\partial^2 R_{22}}{\partial S^2_{12}} \\ & -(1-t_1)C''_1 \end{bmatrix} \begin{bmatrix} \dfrac{dS_{11}}{d\bar{S}_{22}} \\ \dfrac{dS_{12}}{d\bar{S}_{22}} \end{bmatrix} = \begin{bmatrix} 0 \\ -f_1(1-t_2) \left[\dfrac{\partial^2 R_{22}}{\partial S_{T2}\, \partial S_{12}} + \dfrac{\partial^2 R_{12}}{\partial S_{T2} \partial S_{12}} \right] \end{bmatrix}$$

The determinant, D, of the leftmost matrix is necessarily positive according to the second order conditions. Using Cramer's rule, the export displacement effect

(11)

$$\frac{dS_{12}}{d\bar{S}_{22}} = \frac{1}{D} \begin{vmatrix} (1-t_1)(R''_{11} - C''_1) & 0 \\ -(1-t_1)C''_1 & \left\{ -f_1(1-t_2) \left[\partial^2 R_{22} \;/\; \partial S_{T2}\, \partial S_{12} \right\} + \partial^2 R_{12} \;/\; \partial S_{T2}\, \partial S_{12} \right] \end{vmatrix} < 0$$

Since $\partial^2 R_{22} \;/\; \partial S_{T2}\, \partial S_{12} < 0$ and $\partial^2 R_{12} \;/\; \partial S_{T2}\, \partial S_{12} < 0$ if S_{22} and S_{12} are gross substitutes. Parenthetically, our apparatus points to a second effect, the existence of which has been completely ignored to date. It might be called the "home-output displacement effect" of foreign direct investment and is obtained by solving equation (10) for:

$$(12)\quad dS_{11} / d\bar{S}_{22} = \frac{1}{D}\left[-(1-t_1)C_1''\,(1-t_2)f_1\left(\frac{\partial^2 R_{22}}{\partial S_{T2}\,\partial S_{12}} + \frac{\partial^2 R_{12}}{\partial S_{T2}\,\partial S_{12}}\right)\right]$$

Clearly the sign of $dS_{11} / d\bar{S}_{22}$ is determined by the sign of C_1'': the effect will be zero under constant returns to scale.[9]

The result that the export displacement effect is negative when the MNC is considered in isolation might not seem surprising in view of our introductory remarks. But here the conclusion has a different basis from that of most arguments which incorporate the presumption that S_{12} and S_{22} are homogeneous products. In our case the export displacement effect arises directly from the (partial) substitutability assumption. The effect will disappear, i.e. $dS_{12} / d\bar{S}_{22} = 0$, if the goods are independent in consumption, a question which can be addressed empirically.

We adopt $dS_{12} / d\bar{S}_{22}$ as the relevant measure of export displacement because it embodies two essential requirements: it takes account of the alternative position and it is related to the MNC's optimal decisions. The requisite quantity reflects what would happen to MNC exports in the absence of additional direct investment (which assuming constant output/capital ratios will produce proportionate FS sales increases). In the more precise language of our model this amounts to determining the shifts in the equilibrium value of S_{12} caused by relaxing the constraint on S_{22} if initially S_{22} is constrained to a suboptimal fixed value, given the presence of other competing products.

Our definition has the further advantage of flexibility over previous concepts. It is not restricted to extreme situations: rather, its magnitude may vary depending on the empirical substitutability relationships between U.S. export goods and other competing products in foreign markets. It can readily accomodate complementarities (the "associated export effect") should they exist as well as independent goods. It could be modified to take account of intermediate goods - the compensating increase in U.S. exports of parts and components to subsidiaries as S_{22} rises to displace S_{12} - which we are forced to omit owing to data deficiencies.[10] Most importantly, it is directly extensible to the total market setting in which MNC exports and FS products compete with other goods in foreign markets.

This last extension requires that we investigate the shift in the MNC's equilibrium S_{12} decision when the constraint on S_{22} is lifted under circumstances where competing firms equilibrium decisions may also change as a consequence and in turn affect the MNC and its FS. That is, we must employ the full, 6x6, set of market second order conditions. The difficulties of establishing directions and magnitudes for the comparative statics in this case have already been mentioned. We therefore perform this extension numerically in Section IV, where we seek to compute the signs and sizes of the export-displacement and such other, more traditional comparative static effects as the impact on the various outputs of changes in capital costs and tax, tariff and exchange rates. These signs and sizes, which are the important information for policy, depend exclusively on the parameters of the included cost and demand functions. In Section III we present the relevant estimates.

III. Empirical Estimates of Cost, Production and Demand Functions

In this section we present the results of our attempt to estimate empirically the cost and demand function parameters suggested by the model of Section II. Clearly the results can only be treated as rough estimates, as the reader will readily observe. However, despite the ever present problem of comparability, discussed below, the results in the area where we tried the hardest--the estimation of cost functions for competitors--are, we think, encouraging. In any case, we hope that a description of our trials, tribulations and triumphs will in itself be of use to economists and policy-makers. For it cannot be repeated enough: if you want to estimate the effects we discuss, you must estimate, in some way, the magnitudes we sought.

A. The Production Functions and Cost Curves

We have estimated production functions, from which we have derived cost functions, for five markets: the chemicals market in Germany, Canada, and Japan and the electrical machinery market in Germany and Japan. In each market the production functions were estimated for three of the four major classes of competitors: for U.S. exporters, and for native firms and U.S. controlled subsidiaries in the host country. The one class of competitor that we have not adequately covered is the exporters to these markets from third countries. If we had cost estimates for all major exporting countries, then this problem could be solved, either by generalizing our theoretical framework to a multicountry model or by weighting the cost functions of major exporters by their share of trade in a given market. Where it is necessary to estimate the marginal cost of third-country exporters below, we use an average of the costs of the two relevant of our three countries, weighted by their total exports.

The major problems in getting the estimates that we need revolved, as one would expect, around the availability and international comparability of data. Naturally we need data disaggregated by classes of competitors. Further, to investigate the market for commodities that we suspected were close but not perfect substitutes, we felt it important to get data disaggregated as far as possible by product; the selection of the chemical and electrical machinery industries, S.I.T.C. 5 and 72, was an undesired choice made necessary by the unavailability of capital stock and other data at a greater degree of industrial disaggregation for countries other than the United States. Similarly our choice of countries was limited by the same data deficiencies.

The innovation in our empirical work has been to exploit a newly available source of micro-economic data on the costs and production of U.S. foreign subsidiaries. These data, available at present in cross-sections for 1966 and 1970, were made available to us as one of the first users of the Multinational Data System developed at the Bureau of Economic Analysis, U.S. Department of Commerce.[11/]

The results presented in this paper are for 1966, the last full Census year. Rather complete balance sheet and income statement data were available, as is indicated in the Appendix. Although limited in some respects, as is most cross-section data--for example, in the unavailability of a deflated measure of real capital stock--the data and our results compare favorably with recent attempts to estimate production functions from cross-section sources (cf. Griliches and Ringstad [8]).

For this paper separate regressions were run for subsidiaries in each industry and country; in most cases there were ample degrees of freedom, 20 or more; the major exception was the Japanese electrical machinery industry, where our exclusionary rules had to be relaxed to get even 14 observations.

A multitude of sources were used to collect data on native or indigenous producers in each country. The relevant data tables and sources are presented in the Appendix. These data, unfortunately, have several weaknesses: the time series are fairly short, primarily because capital stock data are usually unavailable for years prior to 1957 or so. A fundamental drawback with these series is that the data are aggregates of the operations of both native firms and U.S. foreign subsidiaries. Owing to the lack of comparable time-series on foreign subsidiary operations, it is impossible to obtain clean series for native firms alone. The following table indicates the seriousness of this aggregation problem for each of our cases:

Table 2

Ratio of Foreign Subsidiary Sales to Total Market Sales 1966 12/

	Chemicals	Electrical Machinery
Germany	.06	.13
Japan	.005	.01
Canada	.86	

Clearly the major problem is that in Canada it is hard to talk at all about a native sector in the chemical industry. Fortunately our cost results indicate that there is little difference between the cost estimates for the foreign subsidiary sample and the so-called native firm time-series. The impossibility of clearly isolating native firm characteristics from those of U.S. foreign subsidiaries will persist until either the United States or the host countries decide to provide time-series of adequate production and cost statistics for one class or the other or, preferably, both.

Results for Production Functions

Our major finding was that there was no evidence of increasing returns to scale in either sample. Further, the preponderance of the evidence points to constant returns to scale for each class of competitor. This, of course, is an important result if it holds up. It should be recalled that many of the possible patterns of behavior discussed in the context of theoretical models such as our own and Horst's depend importantly on the presence or absence of increasing or decreasing returns to scale in production. In Horst's model [11], discussed above, the finding of constant costs implies that there will be no interior maximum. Except where tariffs cause distortions, we would observe all production occurring in that locale with the lowest costs of production. In our models, constant costs do not necessarily imply a corner solution of the above sort. However, the slope of the marginal cost curve appears in the second order conditions for each firm and in the matrix of second order conditions for the market as a whole; with constant costs the slope of these marginal cost curves all are equal to zero; hence only the slopes of marginal revenue curves remain in the second order conditions. This, of course, does not mean that costs affect nothing in the model. Marginal cost terms appear in the numerator of many of the comparative static calculations. They also affect the final equilibrium levels of all the outputs of the four classes of competitors.

The results for the native firm regressions were generally so weak that virtually no sensible hypothesis on returns to scale could be rejected. For foreign subsidiaries the results were much more interesting. When materials (plus components) was used as an independent variable along with labor and capital, all three coefficients were usually significantly different from zero; and in the vast majority of cases constant returns to scale could not be rejected at the 5% level of significance. When materials were dropped from the production function, significant decreasing returns to scale were detected for virtually all specifications, unlike the results presented for many previous cross-section studies (e.g., Griliches and Ringstad [8]). However, we feel that the statistical results favor the regressions which include materials. First, the R^2's are greater for these variables--for the same dependent variable, output. Second, and most important, the significance of the coefficient of the materials variable tends to reject the hypotheses that justify the alternative regressions using labor and capital alone: i.e., that materials are (1) linearly related to output or (2) that materials enter in the production process in fixed proportion to output.[13/] Fortunately, we found also that our best production functions also produced our best cost functions.

The results for the best foreign subsidiary and native firm regressions are present in Table 3 below. All such results are for the Cobb-Douglas specification of the production function: $Q = AL^aK^bM^{1-a-b}$. Constant elasticity production functions were also

Table 3

Inter-Country Summary of Production Functions 1/

Country	Type 3/	A	a	b	t	$\bar{R}^2$ (F)	C
Chemical Industry - Native Firms							
Canada	O=f(WL,KI)	2.208 (8.833)	0.433	0.567 (9.880)		.8978 (12.98)	0.490
Germany	O=f(WL,NK,t)	4.523 (7.477)	0.584	0.416 (1.447)	0.025 (1.332)	.8581 (12.09)	0.466
Japan	VA=f(WL,NK,t)	3.247 (18.590)	0.589	0.411 (10.506)	2/	.9854 (431.00)	0.479
United States	O=f(WL,GK)	3.916 (16.116)	0.635	0.365 (5.690)		.7404 (32.3)	0.454
United States (Cross-Section)	O=f(WL,GK)	4.540 (15.333)	0.722	0.278 (4.120)		.3196 (17.0)	0.458
Electrical Industry - Native Firms							
Germany	VA=f(WL,NK,t)	2.033 (2.621)	0,579	0.421 (1.292)	0.044 (1.956)	.7610 (9.551)	0.446
Japan	O=f(WL,NK,t)	7.281 (89.07)	0.759	0.241 (4.51)	2/	.9873 (522.07)	0.558
United States	O=f(WL,GK)	3.640 (76.309)	0.363	0.637 (11.120)		.9177 (123.66)	0.452
United States (Cross-Section)	O=f(WL,GK)	3.425 (31.111)	0.630	0.370 (3.044)		.1956 (9.3)	0.460

(Table 3 cont.)

Inter-Industry Summary of Production Functions

Country	Type	A	a	b	1-a-b	$\bar{R}^2$ (F)	N.Obs.
		Chemical Industry - U.S. Foreign Subsidiaries					
Canada	O=f(WL,NK+INV,M)	0.308 (26.383)	0.170	0.092 (4.116)	0.738 (36.774)	.949 (1138.2)	124
Germany	"	0.301 (12.143)	0.104	0.154 (3.404)	0.742 (15.657)	.945 (292.8)	35
Japan	"	0.258 (5.498)	0.077	0.077 (2.388)	0.846 (18.554)	.943 (190.1)	24
		Electrical Machinery - U.S. Foreign Subsidiaries					
Germany	"	0.334 (11.103)	0.234	0.083 (1.013)	0.683 (11.441)	.931 (101.6)	16
Japan	"	0.374 (8.221)	0.271	0.168 (1.890)	0.561 (6.192)	.905 (53.3)	12

Footnotes to Table 3

1/ Sources: Native firm productionfunctions are taken from Adler, Enders, Preston and Stevens [2]; see especially Chapters 2 and 3. The data are presented in the Appendix to this present paper, section II.

2/ Separate time effects were estimated by year and size class.

3/ The following are the symbols used in defining the type of production function:

O = output (measured in 1966 prices)

WL = payroll (" " " ")

GK = Gross capital stock (all capital variables measured in prices at the time of acquisition).

NK = net capital stock

NK+INV = net capital stock plus inventories

KI = a special capital stock measured calculated by the formula, KI(t) = KI(t-1) + gross investment (t) -.02kI(t-1)

t = time trend

fitted for some specifications for both sets of data. However, for the native firm regressions, Cobb-Douglas forms proved superior to all CES forms; both to maintain symmetry with the native firm results and because one cannot apply CES forms to production functions with more than two inputs without further assumptions,[14/] we have so far limited our investigation of the functions which include materials as a variable to the Cobb-Douglas form. Future work with more general production functions may prove useful: However, Griliches and Ringstad [8] found that, in virtually all cases, the CES did not improve upon the Cobb-Douglas results (p. 63).

In the native firm regressions, as the following tables show, a variety of dependent variables and measures of the capital stock were used; the latter variety was forced upon us by the limited availability of data. In all cases, however, the measure of labor input that seemed to perform best was some form of total payroll--rather than number of employees.

For the foreign subsidiary regressions, a single form performed as well as or better than all others in each country; this used output as the dependent variable and payroll, net capital stock plus inventories and a measure of purchased inputs as the independent variables.[15/]

Cost Functions

Although it is possible to develop the theory of Section II entirely in terms of production functions, we have chosen to do so in terms of cost functions, thus fitting our model into a familiar theoretical framework. This means we have to derive cost functions, either by direct regressions or by deriving them from our production functions.

We have chosen the latter path, thus allowing us to calculate the effects on costs of changes in input and output prices and permitting an independent check on the validity of the production function results.

From the Cobb-Douglas production functions with constant returns to scale, it is well known[16/] that cost functions of the following forms can be derived, making costs a function of the parameters A, a and b of the production function and the prices of labor (w), materials (p_m) and capital services (ccap). Form (13) below corresponds to the production function estimated with materials included and form (14) with materials excluded:

$$(13) \quad C(Q) = \left(\frac{w^a \, ccap^b \, p_m^{\;1-a-b}}{A \, a^a \, b^b \, (1-a-b)^{1-a-b}}\right) Q$$

$$(14) \quad C(Q) = \left(\frac{w^a \, ccap^{1-a}}{A \, a^a \, (1-a)^{1-a}}\right) Q + p_m M$$

In the Table below we present our estimates of the average and marginal costs[17/] for 1966 for each of our four classes of competitors in our five markets. These are derived from the cost function corresponding to the best production functions presented above.[18/] Each estimate assumes that 1966 wage rates and prices of materials prevail; as can be seen in the Appendix these prices cause us no trouble because they are embedded in our estimate of the constant term of the cost function and the 1966 materials/output ratio. However, deriving a figure for the cost of capital services is another, more difficult story. Since in our estimates we, like all other researchers, use measures of the capital stock as inputs and since there are virtually no payments for the annual rental of capital stock, we must derive an independent estimate for the cost of the capital services that are produced annually by the firm's capital stock. As Jorgenson and others have discussed at length,[19] the annual rental price (ccap) in models such as ours of any asset should equal: $r+d-\dot{q}/q$, where r is the firm's cost of capital, d the depreciation rate on the asset and $\dot{q}/q$ the rate of increase of the price (q) of a unit of the asset.

Estimates of the actual depreciation rates on capital assets vary widely. For the U.S. manufacturing sector, rates between 13 and 16% have typically been used.[20] But, in a recent article, Coen[21] has noted that for the industries we are studying the Treasury Department's average useful lives calculations imply the overall depreciation rates of 8.3% and 6.5% for the electrical machinery and chemical industries respectively.

Any estimate of the cost of capital, r, depends importantly on the assumption concerning the financial theory of the firm, the existence of perfect or imperfect capital markets and the like. Little has been done to link the theoretical variations to specific numerical estimates.[22] Here of necessity we shall, like most other empiricists, assume that the firm exists in a perfect capital market. Even so this does not make things much easier; estimates of r for 1966 have varied from .104 (Jorgenson and Hall) down to the Moodies Industrial Bond yield (.053) or even to the average 1966 dividend/price ratio for U.S. manufacturing stocks (.035).

For the United States in 1966, if we exclude the term $-\dot{q}/q$ as most others have, these estimates lead to a possible range of r+d from .0971 to .264. For expository purposes we present estimated costs for the U.S. subsidiaries and parents for a value of ccap equal to .25 for the gross capital stock measure (the measure closest to the domestic measures). This estimate is on the high side of our range, but for the U.S. subs leads to values of predicted costs that are closer to our estimates of actual costs. This value, .25, is also close to the value for native firms that allowed the best prediction for 1966[2].

A note should be added here on the final column of the succeeding table . The calculation of the derivation of actual from predicted costs is based upon an estimate both of actual as well as predicted costs. Costs reported by the companies and subsidiaries do not report actual costs related to capital services in any sense acceptable to economists; depreciation does not reflect, in many cases, actual economic deterioration; and profits need not measure well the cost of capital. Hence for our estimate of "actual" capital costs we have substituted our own figure, ccap times the capital stock measure. This procedure is explained at greater length in the Appendix.

B. The Problem of Demand Function Estimates

For reasons explained briefly below, the estimates of the comparative statics presented in Section IV do not rely on our empirical demand function parameters. Rather, they employ putatively reasonable values of the income, own-price and cross elasticities. The basis for these assumed values is as follows.

Recall from Section II that our theory requires parameters for inverse demand functions of the form $P_{ij} = P_{ij}(\underline{S}_j)$ where i is subscripts products and j, markets, while $\underline{S}_j$ is the relevant goods vector in country j. The requisite parameters can be obtained by inversion from direct demand functions of the form $S_{ij} = S_{ij}(\underline{p}_j, Y_j)$ where $\underline{p}_j$ is the relevant price vector and Y_j denotes income, both in market j. Log-log regressions were used to estimate Cobb-Douglas renditions of the direct demand equations for each of the three products, S_{i2}, i = 1, T, 3, in each foreign market:

(15) $S_{i2} = a_{io2}\, p_{12}^{a_{i12}}\, p_{T2}^{a_{iT2}}\, p_{32}^{a_{i32}}\, Y_2^{a_{i42}}$, where

p_{12} = U.S. wholesale price index for the relevant good;

p_{T2} = Country 2 wholesale price index for the relevant good;

p_{32} = Average of the wholesale prices of major exporters other than the U.S. weighted by their share in exports to 2;[23/] and the a_{ij2}

are the elasticities such that $\sum_{j=1}^{4} a_{ij2} = 0$ in the absence of money illusion. No regressions were run for home-market sales of either U.S. MNC's or third-country firms.

The partial price elasticities may be arrayed to form the 3x3 matrix A_2:

$$\begin{array}{c} \\ S_{12} \\ S_{T2} \\ S_{32} \end{array} \begin{array}{c} \begin{array}{ccc} p_{12} & p_{T2} & p_{32} \end{array} \\ \begin{bmatrix} a_{112} & a_{1T2} & a_{132} \\ a_{T12} & a_{TT2} & a_{T32} \\ a_{312} & a_{3T2} & a_{332} \end{bmatrix} \end{array} = A_2; \text{ and } \qquad \underline{a}_{42} = \begin{bmatrix} a_{142} \\ a_{T42} \\ a_{342} \end{bmatrix}$$

is the column vector of income elasticities. Note that A_2 is not symmetric.[24/] The system of demand equations in country 2 may now be rewritten in log-log form

$$\underline{\log S_2} = I\, \underline{\log a_{o2}} + A_2\, \underline{\log p_2} + B_2\, \underline{\log Y_2}$$

where underlining denotes a vector of logs, I is the identity matrix, $\underline{a}_{o2}$ is the vector of demand-equation constants from above and B_2 is a diagonal matrix with a_{i42} in the ith diagonal element and zeros elsewhere.

Class of Producer	Cost of Capital Services (Gross Capital Basis)	Production Costs per $ of Output (1966 prices)	Total Costs per $ of Output (1966 prices)	Calculated Error of relevant cost prediction for 1966. (Actual-Pred)/ Actual
		United States Electrical		
Native	.25	.67	.81	17%
Native	.25	.80	.94	not calculated for sample
		German Electrical		
Native	.28	.86	.89	+2.4%
Foreign Sub 3/	.25	.81	.82	+17%
Foreign Sub(best)	.25	.90	.91	+10%
		Japan Electrical		
Native	≈.25 2/	.72	.88	+1%
Foreign Sub 3/	.25	.80	.81	2%
Foreign Sub(best)	.25	.80	.84	18%
		United States Chemical		
Native	.25	.73	.95	-3%
Native	.25	.73	.95	not calculated for sample
		Japan Chemical		
Native	≈.25	.69	.89	1%
Foreign Sub 3/	.25	.77	.77	+20.6%
Foreign Sub(best)	.25	.85	.77	+9.8%
		German Chemicals		
Native Firm	.25	.79	.91	< 1%
Foreign Sub 3/	.25	.92	.95	1%
Foreign Sub(best)	.25	.83	.86	11%
		Canada Chemical		
Native	≈.25	.80	.98	-21 %
Foreign Sub 3/	≈.25	.84	.85	+19%
Foreign Sub(best)	≈.25	.94	.95	+11%

1/ Sources: Production functions in Table 3

2/Revalued net fixed assets used; this value was somewhat greater than the book value of net fixed assets.

3/This function used the same form and, wherever possible, the same variables as the best native firm production function.

Solving for the log price vector is a simple computational procedure:

(16) $\underline{\log p_2} = A_2^{-1} \underline{\log S_2} - A_2^{-1} B \underline{\log Y_2} - A_2^{-1} I \underline{\log a_{o2}}$

If the goods are substitutes, we know that the elements of A_2^{-1}, denoted e_{ij2}, will be negative for all i, j[10 , p. 182]. The matrix $(A^{-1}B)$ will be diagonal. Its ith row elements, $c_{i2} = e_{ii2}a_{i42}$, will be negative since $a_{i42} > 0$, as will the coefficients of the constant terms. These provisions are expressed in the signs of the exponents and constants of the ith inverse demand function corresponding to the Cobb-Douglas specification above:[25]

(17) $p_{i2} = C_{io2} S_{12}^{-e_{i12}} S_{T2}^{-e_{iT2}} S_{32}^{-e_{i32}} Y^{C_i}$

where $C_{io2} = (\text{antilog } a_{io2})^{e_{ii2}}$.

Since the marginal revenues of all the competing firms at equilibrium must be positive, we would expect for any reasonable set of estimates of a_{ij2}, that $0 < e_{ij2} < 1$. This expectation is confirmed by the e_{ij2} values which we compute via equation (16) from pre-set price elasticities in Section IV.

In practice, the OLS regressions used to estimate the parameters of equation (1) usually failed to produce significant own-price or cross elasticity coefficients. In two instances, own-price elasticities had significantly negative signs while the cross elasticities did not significantly differ from zero. Equally usually, however, the income elasticities were positive and in the case of both import categories frequently exceeded one by a significant margin.[26] These empirical results are largely useless for our purposes, which, because we are supposing a market of substitutes, require negative own-price elasticities and admit zero cross-elasticities (independent goods) only as a special, somewhat unlikely case. Our alternative for this paper was to pick the plausible elasticity values as specified in Section IV.

IV. Comparative Statics

This section presents the calculations for the changes in the output levels of the multinational firm and its competitors induced by changes in various exogenous variables. First, as detailed above we model the export displacement effect by constraining the output level of the foreign subsidiary and calculating the effects as the constraint is relaxed by one unit. Besides the export displacement effect we have calculated the effects of a (small) change in tariff and income tax rates of the foreign country, the exchange rate of the United States and the cost of capital of the multinational firm.

All such calculations are for small changes in the exogeneous variables at the 1966 equilibrium for either the 6-good market set out above (determining the comparative statics dS_{11}/dX, dS_{12}/dX, dS_{22}/dX, dS_{32}/dX, dS_{33}/dX, dS_{42}/dX, where X is the exogeneous variable) or for the multinational firm alone (determining dS_{11}/dX, dS_{12}/dX, dS_{22}/dX in isolation).

Technically speaking, as is fairly well known the comparative statics of the system of 1st order conditions (7) alone or (7), (8) and (9) of Section II -- are calculated according to Cramer's rule as a ratio of two determinants.[27] The denominator is the determinant of second derivatives of the system -- for the full system the determinant of the matrix set out in Table 1 above; the numerator is that determinant with one column replaced by the column of derivatives of the first order conditions with respect to the exogenous variable, X.

In calculating numerical values for these determinants we have assumed the 1966 values of the prices, quantities, costs and levels of exogenous variables. Thus our estimates attempt to portray a small displacement from the 1966 equilibrium.

We shall use the best cost estimates presented in the last section. As a consequence we assume constant returns to scale and all the cost terms (C''_j) in the matrix of Table 1 become zero. Thus the denominator of our comparative static calculations is a function of slopes of marginal revenue curves and exogeneous variables alone. We shall see below that the effects, particularly their sizes, are very sensitive to the revenue curves assumed.

For all alternative demand curves we have scaled the constant term so that the equation is satisfied for 1966 values. This scaling involved two choices of units of measurement which we do not think affected any of the results. Since our demand functions are Cobb-Douglas, the constant term B_i was defined so that $P_{i,66} S_{i,66} = B_i (S_{i,66})^a (Y_{i,66})^b \prod_{j=1}^{n} (S_j)^{c_j}$, where P and S are price and output, Y is national income and the 66 subscripts indicate 1966 values; a and b, and the c_j's are the assumed elasticities of revenue with respect to quantities and income. Quantities were measured in 1966 price units in the currency of the country where the good was sold. Prices were measured as an index of 1966 prices; hence the actual 1966 price becomes 1.

A. Demand Alternatives and Their Effects

As discussed in the last section we have no demand curve estimates that we believe with any confidence. Hence in the simulations a number of alternatives were tried. One of the most noteworthy developments in our calculations was that variations in the size of the own and cross-elasticities of demand had very marked effects on the results we got; this was true even though in every case all goods remained gross substitutes and the Cobb-Douglas form was maintained.

The demand cases we tried can be described by (1) the absolute size of the own and cross-elasticities (2) their relative size and (3) whether money illusions was present (whether the sum of the price and income elasiticities was different from zero). The spectrum is defined in the following table. The elasticities for a typical equation are presented for each of the cases; the own elasticity is the largest number in absolute value, appearing in the leftmost column.

Demand Alternatives: General Case

Case	Price Elasticities	Income Elastici
1. Normal; no money illusion	-4 +1 +1 +1	+1
2. Normal; money illusion	-2 .2 .2 .2	+1
3. Small Cross Elasticities; no money illusion	-2 .05 .05 .05	1.85
4. Large elasticities; money illusion	-7 2.0 1.0 1.0	1.2

As will be seen below, these small cross-elasticities turned out to be virtually necessary conditions to get all the effects of sign and size that have been customarily assumed in the literature on direct investment.

Cases 1 and 4 led to the violation of the second order conditions for the MNC, as will be discussed more fully below. Consequently,

TABLE 5

Export Displacement Effect

(Small Cross Elasticities; No Money Illusion)

	Chemicals Industry			Electrical Machinery	
	Canada	Germany	Japan	Germany	Japan
S_{22} & S_{42} Identical					
dS_{11}/dS_{22}	0	0	0	0	0
dS_{12}/dS_{22}	-0.04	-0.06	-0.05	-0.06	-0.05
dS_{32}/dS_{22}	-0.001	0.0005	0.0002	0.003	0.0003
dS_{33}/dS_{22}	0	0	0	0	0
dS_{42}/dS_{22}	-0.08	0.64	0.83	0.85	1.08
All Goods Different					
dS_{11}/dS_{22}	0	0	0	0	0
dS_{12}/dS_{22}	-0.04	-0.04	-0.05	-0.04	-0.11
dS_{32}/dS_{22}	-0.001	-0.04	-0.02	-0.03	-0.04
dS_{33}/dS_{22}	0	0	0	0	0
dS_{42}/dS_{22}	-0.002	-0.30	-0.64	-0.52	-6.32
MNC Alone					
dS_{11}/dS_{22}	0	0	0	0	0
dS_{12}/dS_{22}	-0.04	-0.04	-0.05	-0.04	-0.11

Notes:

a. The relevant vector of derivatives of first-order conditions is omitted here since it was derived in essence in Section II.

TABLE 6

The Export Displacement Effect

(Normal Elasticities Case; Money Illusion)

	Chemicals Industry			Electrical Machinery	
	Canada	Germany	Japan	Germany	Japan
S_{22} & S_{42} Identical					
dS_{11}/dS_{22}	0	0	0	0	0
dS_{12}/dS_{22}	-1.41	-0.50	-0.34	-0.84	-0.26
dS_{32}/dS_{22}	0.03	0.18	0.04	0.32	0.01
dS_{33}/dS_{22}	0	0	0	0	0
dS_{42}/dS_{22}	-0.03	1.98	2.02	6.32	3.07
All Goods Different					
dS_{11}/dS_{22}	*	0	0	0	0
dS_{12}/dS_{22}	*	-0.50	-0.33	-1.22	-0.51
dS_{32}/dS_{22}	*	0.03	-0.06	0.39	-1.13
dS_{33}/dS_{22}	*	0	0	0	0
dS_{42}/dS_{22}	*	0.23	-1.61	7.07	-23.8
MNC Alone					
dS_{11}/dS_{22}	*	0	0	0	0
dS_{12}/dS_{22}	*	-0.56	-0.35	-1.10	-0.57

Note: (*) Asterisks indicate that the second order conditions for an MNC manimum are not satisfied.

the Tables and discussion below concentrate on cases 2 and 3.

Cases 1 and 4 demonstrated that the choice of the demand curve often had a significant effect on the second order conditions for the multinational firm. In a number of cases, what we thought were plausible elasticities turned the upper left hand 3x3 block in Table 1 into a positive definite sub-determinant, which implies that the equilibrium is a profit minimum rather than a maximum for the MNC. The major culprit was the second diagonal term which should have been negative: $f_1(1 - t_2)(R''_{12} + \partial^2 R_{22}/\partial S^2_{12})$. The last element of this term, which is always positive, must be outweighed by R''_{12}, which is always negative. This frequently was not the case, particularly when the size of the F.S. sales (R_{22}) were large relative to exports from the United States. This can be appreciated by noting that for the Cobb-Douglas case, $R''_{12} = -e_{112}(1 - e_{112}) \frac{R_{12}}{S^2_{12}}$ and

$\partial^2 R_{22}/\partial S^2_{12} = -e_{212}(-e_{212} -1)R_{22}/S^2_{12}$, where e_{112} is good S_{12}'s own-quantity elasticity and e_{212} is the cross-quantity elasticity of good 2 with respect to good 1. Since $1 - e_{112}$ must be > 0, R''_{12} is negative. Now if for 1966 the revenue from foreign subsidiary sales (R_{22}) is much greater than the revenue from U.S. exports (R_{12}), then unless e_{21} is very near zero, the second positive term will outweigh the negative term. This seems to indicate that we cannot have both the Cobb-Douglas demand case, a rather high cross-elasticity of demand, <u>and</u> observed sales levels that are widely different. The disparate levels of sales that in fact existed in 1966 are also probably responsible for some derivatives that are surprisingly large in absolute (though not percentage) terms--even when all second order conditions are satisfied.

The entire set of comparative statics analyses are presented in Tables 5 through 14. There are two tables for each effect, reflecting the selection of the two different sets of assumptions regarding elasticities as discussed above. The format of the tables is identical. Each presents results for three separate models: (a) the market when S_{22} and S_{42} are treated as identical goods without separate demand parameters; (b) the market allowing S_{22} and S_{42} to be distinct products with, however, the same own and cross elasticities as the others; and (c) the MNC in isolation. For reference we set forth in the table margins the column of derivatives of the first-order conditions with respect to the given exogenous variable, which replaces successive columns in the determinant of the relevant matrix of second-order conditions as each comparative statics effect is calculated.

The Export Displacement Effect

Tables 5 and 6 present the comparative statics for a unit relaxation of the constraint on foreign subsidiary sales. The disparity of the patterns in these tables reveal the variability of this effect, in particular, with respect to demand conditions abroad. As one would expect, the smaller the cross elasticities, the smaller will be the shifts in the equilibrium quantities caused by dS_{22}. The "home-output displacement effect," dS_{11}/dS_{22}, is zero everywhere, since we incorporate our finding of constant marginal costs. Reading from the bottom, the results for the MNC considered in isolation hold few surprises. The export displacement effect, dS_{12}/dS_{22}, is invariably negative if the goods are substitutes as predicted by equation (11) above. If the cross elasticities are sufficiently large, however, we get the unusual possibility for the Table 6-cases of the German and Canadian chemicals industries, when cross elasticities are relatively large, that $dS_{12}/dS_{22} < -1$. This outcome is probably unlikely in practice and is not observed in Table 5. It doubtless arises as a result both of the Cobb-Douglas specification of the demand functions and the particular numerical relationships among the specified own-price and cross elasticities which affect the size and can change the sign of the second diagonal element of the market matrix in Table 1, as mentioned above.

The sensitivity to specification underlies the variety of patterns which are revealed in the full-market context. When all four products are assumed to be differentiated and cross-elasticities are relatively small, the Table 5-shifts in all equilibrium sales values with respect to dS_{22} are negative as one might surmise on prior grounds. A puzzle is the large displacement of native firm sales in the Japanese electrical machinery industry which is repeated in the comparable case in Table 6. What disturbs preconceptions, however, is that when cross elasticities grow relative to own elasticities and all products are differentiated, Table 6 shows that the universal negativity of all effects breaks down. Several unfamiliar patterns emerge. While U.S. exports seem always to be diminished, the effect on native firm sales and third country exports can become either negative or, startlingly, positive. Similar positivity is evident when S_{22} and S_{42} are constrained to be identical.28/

While the demand assumptions seem reasonable and have been used by others some of our results seem empirically implausible. Consider the case where $dS_{12}/dS_{22} < 0$, $0 < dS_{32}/dS_{22} < 1$ and $dS_{42}/dS_{22} > 1$. Baldly interpreted, a unit increase in FS sales will displace U.S. exports, encourage host country imports from third countries and generate additional native firm sales of more than one unit. Are F.S. sales an engine of growth? We think not. But we do not hesitate to point out that our results reveal exceptions to common expectations and to insist that the demand-parameter measurements we seek are a prerequisite for policy to be aimed accurately.

Exchange Rate Changes.

Tables 7 and 8 provide the comparative statics for a devaluation of the dollar relative to all other currencies. Our analysis is necessarily incomplete for our model excludes macro-economic policy relationships and therefore omits all considerations relating to price and income changes flowing from the international adjustment process. A consequence of this omission is that both exporters' home-market sales, S_{11} and S_{33}, remain unaffected by the devaluation.

Nonetheless, the results tend both to confirm simple prior expectations and therefore to reinforce belief in our approach. *Ceteris paribus*, one would expect a dollar devaluation to increase optimal MNC exports and to reduce its equilibrium level of foreign production. This pattern is apparent in all instances, under both sets of elasticity assumptions. One would also expect optimal third country exports, S_{32}, and native firm sales, S_{42} to decline. Generally this is indeed the case. The possibility remains (Canadian chemicals and Japanese electrial machinery) that interactive demand effects can reduce the incidence of the devaluation on S_{32} to the point that $dS_{32}/df_1 > 0$.

The magnitudes in Tables 7 and 8 are meaningless without further interpretation. The derivatives are expressed in millions of currency units of good S_{ij} per dollar change in the exchange rate, f_1. Clearly a dollar change in the 1966 exchange rate for any of these countries would have been an enormous one (e.g. about a 400% increase in the German case). However, we can use the derivative to calculate the effect of more realistic changes, say a 10% devaluation of the dollar with respect to each currency. The absolute effect of such a devaluation would be found by multiplying the respective columns by the following constants: .0926; .0251; .000276; .0251; .000276.

In many cases the sizes of these effects seem quite reasonable. Thus, taking the effect on U.S. exports to the host country as an example, the absolute effects in the first non-zero row of Table 7 imply the following percentage changes in export quantities (measured in 1966 dollars) for a 10% devaluation of the dollar: 23% for Canadian chemicals; 22.5% for German chemicals; 21% for Japanese chemicals; 23.5% for German electrical machinery; 20% for Japanese electrical machinery. (see Table A4).

Table 7

Comparative Statics for a Change in Country 2's Exchange Rate[a]
(Small Cross Elasticities: No Money Illusion)

	Chemicals Industry			Electrical Machinery	
	Canada	Germany	Japan	Germany	Japan
S_{22} & S_{42} Identical					
dS_{11}/df_1	0	0	0	0	0
dS_{12}/df_1	0.11×10^{4}	0.64×10^{4}	0.60×10^{8}	0.41×10^{4}	0.22×10^{8}
dS_{22}/df_1	-0.014×10^{4}	-0.008×10^{4}	-0.003×10^{8}	-0.005×10^{4}	-0.38×10^{4}
dS_{32}/df_1	-0.0007×10^{4}	-0.063×10^{4}	-0.020×10^{8}	-0.041×10^{4}	-0.25×10^{6}
dS_{33}/df_1	0	0	0	0	0
dS_{42}/df_1	-0.0001×10^{4}	-0.43×10^{4}	-0.52×10^{8}	-0.69×10^{4}	-0.44×10^{8}
All Goods Different					
dS_{11}/df_1	0	0	0	0	0
dS_{12}/df_1	0.11×10^{4}	0.61×10^{4}	5835×10^{4}	38×10^{4}	2207[illegible]^{4}
dS_{22}/df_1	-0.013×10^{4}	-0.052×10^{4}	$-369.\times10^{4}$	$-.040\times10^{4}$	-91×10^{4}
dS_{32}/df_1	0.0007×10^{4}	-0.059×10^{4}	$-190.\times10^{4}$	$-.037\times10^{4}$	-22×10^{4}
dS_{33}/df_1	0	0	0	0	0
dS_{42}/df_1	$-.0011\times10^{4}$	-0.45×10^{4}	-5267.10^{4}	$-.67\times10^{4}$	-3929×10[illegible]
MNC Alone					
dS_{11}/df_1	0	0	0	0	0
dS_{12}/df_1	0.11×10^{4}	$.61\times10^{4}$	5827×10^{4}	0.38×10^{4}	2205×10^{4}
$dS_{22}/$	-0.013×10^{4}	-0.054×10^{4}	$-379.\times10^{4}$	-0.042×10^{4}	$-92.\times10^{4}$

Note (a) The relevant derivatives of the first-order conditions in (7), (8) and (9) taken with respect to f_1, and transposed to form a row vector are:

$$\left[0,\ -(1-t_2)\ (dR_{22}/dS_{12}+dR_{12}/dS_{12}),\ 0,\ 0,\ 0,\ 0\right]$$

Table 8

Comparative Statics for a Change in Country 2's Exchange Rate
(Normal Elasticities Case: No Money Illusion)

	Chemicals Industry			Electrical Machinery	
	Canada	Germany	Japan	Germany	Japan
S_{22} & S_{42} Identical					
dS_{11}/df_1	0	0	0	0	0
dS_{12}/df_1	2.09×10^4	1.30×10^4	$.85\times10^8$	1.34×10^4	$.24\times10^8$
dS_{22}/df_1	$-.87\times10^4$	$-.069\times10^4$	$-.016\times10^8$	$-.06\times10^4$	$-.00018\times10^8$
dS_{32}/df_1	$-.05\times10^4$	$-.52\times10^4$	$-.11\times10^8$	$-.54\times10^4$	$-.01\times10^8$
dS_{33}/df_1	0	0	0	0	0
dS_{42}/df_1	$-.006\times10^4$	-3.51×10^4	-2.93×10^8	-8.89×10^4	-1.89×10^8
All Goods Different					
dS_{11}/df_1	*	0	0	0	0
dS_{12}/df_1	*	1.40×10^4	$.83\times10^8$	3.69×10^4	1.20×10^8
dS_{22}/df_1	*	$-.58\times10^4$	$-.282\times10^8$	-1.78×10^4	-1.91×10^8
dS_{32}/df_1	*	$-.50\times10^4$	$-.093\times10^8$	-1.36×10^4	$.245\times10^8$
dS_{33}/df_1	*	0	0	0	0
dS_{42}/df_1	*	-3.82×10^4	-2.57×10^8	-24.52×10^4	43.56×10^8
MNC Alone					
dS_{11}/df_1	*	0	0	0	0
dS_{12}/df_1	*	1.35×10^4	$.81\times10^8$	3.34×10^4	1.17×10^8
dS_{22}/df_1	*	$-.64\times10^4$	$-.30\times10^8$	-1.87×10^4	-1.66×10^8

NOTE: Asterisks indicate cases where the second order conditions for an MNC profit maximum are not satisfied

Table 9

Comparative Statics for Tariff Change in Country 2.[a]
(Small Cross Elasticities; No Money Illusion)

	Chemicals Industry			Electrical Machinery	
	Canada	Germany	Japan	Germany	Japan
S_{22} & S_{42} Identical					
$dS_{11}/d\tau_2$	0	0	0	0	0
$dS_{12}/d\tau_2$	-0.22×10^{4}	-1.21×10^{4}	-1.15×10^{8}	-0.77×10^{4}	-41.74×10^{6}
$dS_{22}/d\tau_2$	0.03×10^{4}	0.02×10^{4}	0.005×10^{8}	0.01×10^{4}	0.007x1[illegible]
$dS_{32}/d\tau_2$	-0.04×10^{4}	-0.90×10^{4}	0.03×10^{8}	-0.53×10^{4}	0.42×10^{6}
$dS_{33}/d\tau_2$	0	0	0	0	0
$dS_{42}/d\tau_2$	0.0006×10^{4}	1.00×10^{4}	1.00×10^{8}	1.54×10^{4}	83.03×10^{6}
All Goods Different					
$dS_{11}/d\tau_2$	0	0	0	0	0
$dS_{12}/d\tau_2$	-0.22×10^{4}	-1.22×10^{4}	-1.15×10^{8}	-0.78×10^{4}	-41.92×10^{6}
$dS_{22}/d\tau_2$	0.04×10^{4}	0.12×10^{4}	0.07×10^{8}	0.09×10^{4}	1.73×10^{6}
$dS_{32}/d\tau_2$	-0.04×10^{4}	-0.91×10^{4}	0.03×10^{8}	-0.53×10^{4}	0.37×10^{6}
$dS_{33}/d\tau_2$	0	0	0	0	0
$dS_{42}/d\tau_2$	0.004×10^{4}	1.11×10^{4}	1.04×10^{9}	1.66×10^{4}	74.84×10^{6}
MNC Alone					
$dS_{11}/d\tau_2$	0	0	0	0	0
$dS_{12}/d\tau_2$	-0.23×10^{4}	-1.23×10^{4}	-1.15×10^{8}	-0.79×10^{4}	42.0×10^{6}
$dS_{22}/d\tau_2$	0.03×10^{4}	0.11×10^{4}	0.07×10^{8}	0.09×10^{4}	0.2×10^{6}

a/ The relevant derivatives of the first-order conditions in (7), (8), and (9), taken with respect to τ_2 and arranged as a row vector.

$$\left[0,\ (1-t_2)\ C_1^1,\ 0,\ (1-t_2)\ C_3^1,\ 0,\ 0\right]$$

Increasing Tariffs in Country 2.

The comparative statics analysis of this case appears in Tables 9 and 10. All other things being equal one would expect a tariff increase in country 2 to reduce the MNC's optimal exports to country 2 and to raise the equilibrium level of its FS sales. This expectation is confirmed unambiguously in all cases. One would also expect the tariff increase to protect native firms and cause the optimal level of S_{42} to rise. This expectation is also largely confirmed with Japan's electrical machinery industry being a possible exception.

Somehow, a uniform tariff increase might be expected to reduce imports from all sources especially when the import products are similar, though not identical. Our model, however, tells us clearly that this need not be the case. There are several instances where $dS_{32}/d\tau_2 > 0$. When cross elasticities are small, these cases are confined to Japan. But when the cross elasticities are larger (Table 10) $dS_{32}/d\tau_2$ turns positive more frequently. There is no obvious explanation for this unusual result.

The Effect of a Rise in Country 2's Tax Rate.

Tables 11 and 12 set forth the relevant comparative statics. All others exogenous factors held constant, one would expect a rise in t_2 to raise equilibrium MNC exports and reduce optimal F.S. sales. This result is apparent in all versions of the model under both sets of elasticity assumptions.

It is interesting that the effect on native firm sales, dS_{42}/dt_2, is usually also negative. It is well known that corporate

Table 10

Comparative Statics for a Rise in Country 2's Tariff Rate
(Normal Elasticities Case: No Money Illusion)

	Chemicals Industry			Electrical Machinery	
	Canada	Germany	Japan	Germany	Japan
S_{22} & S_{42} Identical					
$dS_{11}/d\tau_2$	0	0	0	0	0
$dS_{12}/d\tau_2$	-3.82×10^{4}	-2.39×10^{4}	-1.64×10^{8}	-2.44×10^{4}	$-.458\times10^{8}$
$dS_{22}/d\tau_2$	1.64×10^{4}	$.142\times10^{4}$	$.032\times10^{8}$	$.117\times10^{4}$	$.0003\times10^{8}$
$dS_{32}/d\tau_2$	$.055\times10^{4}$	$-.082\times10^{4}$	$.218\times10^{8}$	$.358\times10^{4}$	$.020\times10^{8}$
$dS_{33}/d\tau_2$	0	0	0	0	0
$dS_{42}/d\tau_2$	$.013\times10^{4}$	7.24×10^{4}	5.71×10^{8}	17.28×10^{4}	3.64×10^{8}
All Goods Different					
$dS_{11}/d\tau_2$	*	0	0	0	0
$dS_{12}/d\tau_2$	*	-3.95×10^{4}	-2.02×10^{8}	-12.17×10^{4}	-2.46×10^{8}
$dS_{22}/d\tau_2$	*	1.71×10^{4}	$.685\times10^{8}$	5.94×10^{4}	3.91×10^{8}
$dS_{32}/d\tau_2$	*	$.356\times10^{4}$	$.221\times10^{8}$	3.86×10^{4}	$-.502\times10^{8}$
$dS_{33}/d\tau_2$	*	0	0	0	0
$dS_{42}/d\tau_2$	*	11.72×10^{4}	6.25×10^{8}	82.08×10^{4}	-89.0×10^{8}
MNC Alone					
$dS_{11}/d\tau_2$	*	-3.89×10^{4}	-1.98×10^{8}	-11.16×10^{4}	-2.39×10^{8}
$dS_{12}/d\tau_2$	*	1.83×10^{4}	$.735\times10^{8}$	6.23×10^{4}	3.39×10^{8}
$dS_{22}/d\tau_2$					

NOTE: Asterisks indicate cases where the second-order conditions for an MNC profit maximum are not satisfied.

Table 11

Comparative Statics for an Increase in Country 2's Tax Rate[a/]
(Small Cross Elasticities: No Money Illusion)

	Chemicals Industry			Electrical Machiner	
	Canada	Germany	Japan	Germany	Japa
S_{22} & S_{42} Identical					
dS_{11}/dt_2	0	0	0	0	0
dS_{12}/dt_2	0.31×10^4	1.94×10^4	2.55×10^8	1.24×10^4	1.02×10^8
dS_{22}/dt_2	-0.05×10^4	-0.03×10^4	-0.01×10^8	-0.02×10^4	-0.02×10^7
dS_{32}/dt_2	0.05×10^4	0.77×10^4	-0.08×10^8	0.43×10^4	-0.11×10^7
dS_{33}/dt_2	0	0	0	0	0
dS_{42}/dt_2	-0.001×10^4	-1.48×10^4	-2.21×10^8	-2.29×10^4	-2.04×10^8
All Goods Different					
dS_{11}/dt_2	0	0	0	0	0
dS_{12}/dt_2	0.34×10^4	1.98×10^4	2.56×10^8	1.27×10^4	1.03×10
dS_{22}/dt_2	-0.06×10^4	-0.18×10^4	-0.16×10^8	-0.14×10^4	-0.04×10
dS_{32}/dt_2	0.05×10^4	0.78×10^4	-0.08×10^8	0.43×10^4	-0.001x1
dS_{33}/dt_2	0	0	0	0	0
dS_{42}/dt_2	-0.005×10^4	-1.66×10^4	-2.31×10^8	-2.48×10^4	-1.84×10
MNC Alone					
dS_{11}/dt_2	0	0	0	0	0
dS_{12}/dt_2	0.34×10^4	1.98×10^4	2.56×10^8	1.27×10^4	1.03×10
dS_{22}/dt_2	-0.04×10^4	-0.18×10^4	-0.17×10^8	-0.14×10^4	-0.04×10

a/ The relevant vector of derivatives of first order conditions, (7), (8) and (9), with respect to t_2 is transposed:

$$\left[0,\ f_1\ (\partial R_{22}/\partial S_{12} + \partial R_{12}/\partial S_{12}) - (1-T_2)C_1^1,\ 0,\ f_2\ (\partial R_{32}/\partial S_{32}) - (1+T_2)C_3^1,\ 0,\ 0\right]$$

income tax changes do not change the optimal output decisions of one-country firms considered in isolation. Clearly, an exception to this rule may emerge when the firms are considered in a market context, as a consequence of the shift of demand to imports. This shift is not complete, however. For reasons that are not obvious, the tax-rate change may move the equilibrium level of S_{32} either upwards or downwards.

Comparative Statics for a Change in the Cost of Capital

The cost of capital, denoted above by r, is just another cost, one element of the annual rental price of a unit of a firm's capital stock (CCAP). This annual rental price appears in the Cobb-Douglas cost functions, equations (13) and (14) above. The rate of change of costs with respect to changes in r is a function of the capital elasticity b: $\partial C/\partial r = bC/ccap$.

For a single firm producing one product whose price and marginal revenue is unaffected by changes in r, it is clear that an increase in the cost of capital causes a reduction in the equilibrium output of the firm. However, there can be many variations on this theme when a production process becomes one of many in a multinational firm. First is the question of the dependence of the marginal revenue curve of a given product on the prices of substitutes, these latter perhaps being affected by the increased cost of capital. Second is the question of whether the cost of capital for operations in one locale is related to, independent of, or identical to that in another. Independence, of course, will be the rule if the international capital market is perfect. It might be true only for all operations of a given MNC if the MNC can overcome imperfections that beset smaller, native firms.

In this comparative static calculation we assume that all operations of the MNC possess the same cost of capital, .25 on a gross capital basis, but that it is at least partially independent of the cost of capital of native and third-country firms. Of course, alternative variations can easily be computed.

In the small elasticities case, Table 13, we see that, if the multinational firm is taken in isolation, the sign of the changes of sales is negative apart from two exceptions. One would expect these exceptions to the one good case to multiply as one gave fuller play to cross elasticities of demand--by either increasing the cross-elasticities directly or embedding the MNC in a wider market.

And that is what we see in the tables. In the normal elasticities case, Table 14, the exceptions increase to four, still taking the MNC in isolation. In the 6x6 market, even when cross elasticities are small, there are numerous cases of dS_{12}/dr and dS_{22}/dr being greater than zero.

TABLE 12

Comparative Statics for an Increase in Country 2's Tax Rate
(Normal Elasticities Case: No Money Illusion)

	Chemicals Industry			Electrical Machinery	
	Canada	Germany	Japan	Germany	Japan
<u>S_{22} & S_{42} Identical</u>					
dS_{11}/dt_2	0	0	0	0	0
dS_{12}/dt_2	$5.45*10^4$	$3.93*10^4$	$3.65*10^8$	$4.01*10^4$	$1.13*10^8$
dS_{22}/dt_2	$-2.34*10^4$	$-.22*10^4$	$-.07*10^8$	- .19*104	$-.0008*10^8$
dS_{32}/dt_2	$-.08*10^4$	$-.56*10^4$	$-.49*10^8$	$-1.03*10^4$	$-.05*10^8$
dS_{33}/dt_2	0	0	0	0	0
dS_{42}/dt_2	$-.02*10^4$	$-11.3*10^4$	$-12.66*10^8$	$-27.56*10^4$	$-8.94*10^8$
<u>All Goods Different</u>					
dS_{11}/dt_2	*	0	0	0	0
dS_{12}/dt_2	*	$6.64*10^4$	$4.48*10^8$	$20.68*10^4$	$6.04*10^8$
dS_{22}/dt_2	*	$-2.82*10^4$	$-1.52*10^8$	$-10.05*10^4$	$-9.60*10^8$
dS_{32}/dt_2	*	$-1.34*10^4$	$-.50*10^8$	$-7.04*10^4$	$1.23*10^8$
dS_{33}/dt_2	*	0	0	0	0
dS_{42}/dt_2	*	$-19.07*10^4$	$-13.86*10^8$	$-138.56*10^4$	$218.50*10^8$
<u>MNC Alone</u>					
dS_{11}/dt_2		0	0	0	0
dS_{12}/dt_2	*	$6.50*10^4$	$4.39*10^8$	$18.86*10^4$	$5.87*10^8$
dS_{22}/dt_2	*	$-3.05*10^4$	$-1.63*10^8$	$-10.53*10^4$	$-8.31*10^8$

Note: *Asterisks indicate that the second order conditions for an MNC profit maximum are <u>not</u> satisfied.

Table 13

Comparative Statics for a Change in the MNC's Cost of Capital[9)]
(Small Cross Elasticities; No Money Illusion)

	Chemicals Industry			Electrical Machinery	
	Canada	Germany	Japan	Germany	Japan
S_{22} & S_{42} Identical					
dS_{11}/dr	-17.93	-17.93	-17.93	-18.25	-18.25
dS_{12}/dr	0.53	-1.16	-1.25×10^4	-0.74	-0.45×10^4
dS_{22}/dr	-17.51	-1.75	36.35	-1.18	-0.47×10^4
dS_{32}/dr	0.02	0.12	417.1	0.08	0.51×10^4
dS_{33}/dr	0	0	0	0	0
dS_{42}/dr	1.39	-0.29	1.08×10^4	0.33	0.89×10^4
All Goods Different					
dS_{11}/dr	-17.93	-17.93	-17.93	-18.26	-18.26
dS_{12}/dr	1.10	-1.02	1.25×10^4	-0.66	0.45×10^4
dS_{22}/dr	-32.66	-5.78	0.07×10^4	-3.79	0.02×10^4
dS_{32}/dr	5.03	0.35	0.04×10^4	0.19	0.45×10^2
dS_{33}/dr	0	0	0	0	0
dS_{42}/dr	7.85	2.72	1.14×10^4	3.45	0.81×10^4
MNC Alone					
dS_{11}/dr	-17.93	-17.93	-17.93	-18.25	-18.25
dS_{12}/dr	1.11	-1.02	-1.25×10^4	-0.65	-0.45×10^4
dS_{22}/dr	-32.62	-5.77	0.07×10^4	-3.79	0.02×10^4

9) The relevant derivatives of the first-order conditions in (7), (8) and (9), taken with respect to the cost of capital, r, and transposed into a vow vector are:

$$\left[(1-t_1)C_1'(\partial C_1'/\partial r),\ (1-t_2)C_1'(1+\tau_2)\partial C_1'/\partial r,\ f_2(1-t_2)C_2'\partial C'_2/\partial r.\ 0,\ 0,\ 0 \right]$$

Table 14

Comparative Statics foran Increase in the MNC's Cost of Capital
(Normal Elasticities Case: No Money Illusion)

	Chemicals Industry			Electrical Machinery	
	Canada	Germany	Japan	Germany	Japan
S_{22} & S_{42} Identical					
dS_{11}/dr	$-14.90*10^4$	$-14.90*10^4$	$-14.90*10^4$	$-15.25*10^4$	$-15.25*10^4$
dS_{12}/dr	$-3.63*10^4$	$-2.83*10^4$	$-1.98*10^8$	$-2.92*10^4$	$-.549*10^8$
dS_{22}/dr	$1.13*10^4$	$.036*10^4$	$.036*10^8$	$.054*10^4$	$.0003*10^8$
dS_{32}/dr	$.093*10^4$	$1.13*10^4$	$.267*10^8$	$1.17*10^4$	$.025*10^8$
dS_{33}/dr	0	0	0	0	0
dS_{42}/dr	$.040*10^4$	$7.57*10^4$	$6.86*10^8$	$19.27*10^4$	$4.36\ ^{8}$
All Goods Different					
dS_{11}/dr	*	$-14.90*10^4$	$-14.90*10^4$	$-15.25*10^4$	$-15.25*10^4$
dS_{12}/dr	*	$-4.26*10^4$	$-2.43*10^8$	$-13.28*10^4$	$-2.94*10^8$
dS_{22}/dr	*	$1.24*10^4$	$-0.81*10^8$	$6.09*10^4$	$-2.94*10^8$
dS_{32}/dr	*	$1.62*10^4$	$.27*10^8$	$4.95*10^4$	$-.598*10^8$
dS_{33}/dr	*	0	0	0	0
dS_{42}/dr	*	$12.42*10^4$	$7.53*10^8$	$89.08*10^4$	$-106.16*10^8$
MNC Alone					
dS_{11}/dr	*	$-14.90*10^4$	$-14.90*10^4$	$-15.25*10^4$	$-15.25*10^4$
dS_{12}/dr	*	$-4.12*10^4$	$-2.38*10^8$	$-12.01*10^4$	$-2.86*10^8$
dS_{22}/dr	*	$1.43*10^4$	$.87*10^8$	$6.39*10^4$	4.[illegible]10^8

NOTE: Asterisks indicate that the second-order conditions for an MNC profit maximum are not satisfied.

V. Concluding Remarks

The comparative static results are the end of our story. They reveal to policy-makers, we think, the dangers of ignoring market interactions between the MNC and its competitors and acting on simple assumptions which do not take these effects into account.

To economists and policy-makers we hope a further, theoretical, implication comes through. It is possible to model the trade-direct investment nexus. By deriving and estimating the demand and cost functions of the major competitors in a market, it is then possible to answer the question so many have despaired of answering: what would have happened if the direct investment had not been made?

But successful prediction requires an accurate picture of the world. As is so often the case, the accuracy of our view of the trade-direct investment nexus is marred by severe empirical problems. To fully test this model we especially need the data to permit more refined estimates of demand functions. It is to be hoped that modern demand theory, the thrust of which is to estimate demand systems rather than functions for individual products in isolation, can find a useful application here.

In the matter of cost function estimates, too, further advances are required though we believe our work has made useful progress. It is too frequently asserted that MNC's enjoy scale economies, and too many predictions are based on this assumption, for our finding of everywhere constant returns to scale to go unquestioned. And if MNC's produce identical goods at home and abroad, data refinements will have to be sought to make comparable cost function estimates from different parts of the world. This last is an important issue in the study of the causes and balance of payments and employment effects of the international migration of specific industries.

Finally, a few caveats. Our work is hardly the last word on export displacement. Our model perforce elided the problem of trade in intermediate goods. It cannot accommodate the macro-economic changes which accompany the international adjustment process. It also is non-dynamic and thus does not incorporate restrictions on substitutability that might be required for dynamic stability. In its present version it ignores uncertainty. Finally, we have calculated only the effects of small changes in exogenous variables; we have not solved the model for its equilibrium values or simulated the effects of large displacements from an initial equilibrium. These sins of omission should be corrected in future work. We hope to have made a fruitful beginning.

Appendix

The Cobb-Douglas cost function as described above (equation (13)), makes costs (C) a function of output (Q) and:

w	=	the wage rate
ccap	=	the rental price of capital services
Pm	=	the price of a unit of raw materials
A	=	the constant term of the corresponding Cobb-Douglas production function
a,b,c	=	the elasticities of output with respect to labor, capital and raw materials; since returns to scale are constant c = 1 - a - b.

Thus we have the functional relationship:

$$\text{(A1)} \quad C(Q) = \left[\frac{w^a \; ccap^b \; Pm^c}{A \; a^a \; b^b \; c^c} \right] Q$$

It would appear that once A, a, b, and c are estimated from the production function it should be an easy matter to plug in the proper values for wages and the costs of other inputs and then calculate costs for any level of output.

However, there are intricate problems of scaling A, w, ccap and Pm that have made the derivation of our cost functions a difficult task. The major problem is that the estimate of A for the production function is affected by the units of measurement of <u>all</u> the independent variables entering into the production function. The size and the units of measurement of A change as the definitions and/or units of measurement of A change. The problem of deriving cost functions from the production function estimates really boils down to making the proper transformations on either the received values of A or the input prices (w, ccap, Pm) in order to express the composite term bracketed in equation A1 in the units , dollars per unit of output. This unit of output must correspond to the units in which output is measured.

A detailed discussion of the scaling transformations necessitated in this study can be found in Adler, et al. [2], Chapter II. Here we will briefly go through our procedures.

As mentioned in Section III, labor input was measured as the wage bill; this can be interpreted as a weighted average of labor inputs of different qualities $[\Sigma w_i L_i]$ or as the wage times labor input of a single skill category. We assumed the former, but for illustrative purposes will here assume the latter. It can easily be shown that, for a Cobb-Douglas production function, measuring labor inputs in dollar values (at some base year price, $\bar{w}$) does not change the estimate of the elasticity a but <u>does</u> change the estimate of A by the factor $\bar{w}^{\hat{a}}$, where $\hat{a}$ is the estimated value of the true labor elasticity, a. This can be understood heuristically by noting how the constant term can be changed in $Q = A\ L^a\ K^b$ when $\bar{w}L$ is substituted for L; we then have:

$$Q = A\ (\bar{w}L)^a\ K^b = (A\bar{w}^a)\ L^a\ K^b = A^1\ L^a\ K^b,$$

where A^1 now equals $A\bar{w}^a$. Likewise, in a regression for this type of function, multiplying any variable by a constant (k) changes the value of the estimated regression constant term by the factor k^e, where e is the exponent of the variable in the production function.

In our regressions all variables were expressed in base year price units; let $\bar{p}$, $\bar{q}$, $\bar{w}$, $\bar{p}_m$ be the base year price unit for output, the capital stock, labor and materials. We also have an added problem that we need a measure of capital services, cs , rather than a measure of capital stock. By arguments identical to the previous one, it can be shown that the estimated constant term of the production function ($\hat{A}$) is related to the estimate we desire and would get if everything were measured in quantity units (A*) by the following formula:

$$\hat{A} = \frac{A^* \ \bar{p} \ x^{\hat{b}}}{\bar{w}^{\hat{a}} \ \bar{q}^{\hat{b}} \ \bar{p}_m^{\hat{c}}} ,$$

where all the symbols have been introduced except x, the ratio of capital services (cs) to capital stock: cs = xK.

We need A* in the denominator of the cost function and we do not have x and the base year prices, $\bar{p}$, $\bar{w}$, $\bar{q}$, $\bar{p}_m$ that are distorting the estimate $\hat{A}$. We can, however, undo the effect on A* by expressing the price variables in the cost function as appropriate price indices--thus basically multiplying or dividing factors that multiply $\hat{A}$ in equation A1, rather than changing $\hat{A}$ itself. It can be verified that if we express each input price in equation A1 as an index with the same base as was used in the estimation of the production function (i.e., with bases $\bar{w}$, $\bar{q}$, $\bar{p}_m$), then the overall cost function will be identical to the one in equation A1. Thus we calculate costs, for any spectrum of input prices and output levels, using the following:

$$\text{(A2)} \quad C(Q) = \frac{\left(\frac{w}{\bar{w}}\right)^{\hat{a}} \left(\frac{x \cdot ccap}{\bar{q}}\right)^{\hat{b}} \left(\frac{p_m}{\bar{p}_m}\right)^{\hat{c}}}{\hat{A} \ \hat{a}^{\hat{a}} \ \hat{b}^{\hat{b}} \ \hat{c}^{\hat{c}}} \quad (\bar{p}Q)$$

It should be noted that the value x times ccap is the cost of a unit of capital service times the number of units of capital services per unit of capital stock: i.e., the cost of the value of capital services produced by one unit of capital stock. This latter is equal, under our assumptions, to $q(r + d - \dot{q}/q)$, as defined in Section III.

Finally, it should be noted that when calculating costs for the input prices that existed in the base year, the term $w/\bar{w}$ and p_m/p_m both become 1, and $x \cdot ccap/\bar{q}$ becomes $r+d-\dot{q}/q$.

II. Data

The first table in this section shows the balance sheet and income statement data gathered from foreign subsidiaries in the 1966 Census.

Succeeding this are the 1966 values for S_{12}, S_{22}, S_{32} and S_{24} for each of the five country-industry cases. Finally, we report data used to estimate the native firm production functions.

Foreign Subsidiary Data

Table A1

Item **Note:** Lines n and t should equal line j.	12-31-66 (or date) In currency used on books of allied foreign organization *(Specify)*
ASSETS	28
a. Cash, government securities and other cash items	
b. Trade accounts receivable	
c. Inventories	
d. Other current assets	
e. Total current assets (line a - d)	
f. Investments in & advances to subsidiaries, affiliates & branches	
g. Property, plant and equipment, at cost	
h. Less: Accumulated reserves	
i. Deferred charges and other assets	
j. Total assets (line e-i)	
LIABILITIES	
k. Current liabilities	
l. Long-term debt	
m. Other liabilities, including underlying minority interests	
n. Total liabilities (line k - m)	
NET WORTH OR SHAREHOLDERS' EQUITY	
o. Capital stock	
p. Capital surplus	
q. Retained earnings or earned surplus	
r. Surplus reserves	
s. Home office account of branches, net proprietorship account, or partnership account	
t. Total net worth or shareholders' equity (line o - s)	

Item	Year ended 12-31-66 (In currency used on books of foreign organization *(Specify)*
INCOME	38
Net sales of goods or services, total	
Dividends, interest, profits, royalties and fees received from foreign secondary operations	
Other income *(Identify principal type)*	
Total income (lines a - c)	
COSTS AND EXPENSES	
Costs of goods and services purchased	
Compensation of employees	
Depreciation, amortization and retirement of property, plant and equipment	
Depletion of natural resources	
Interest	
Taxes other than income taxes (include excise taxes levied on company if included in line a)	
Provision for foreign income taxes	
Other costs and charges, including adjustment for underlying minority interest share in profit or loss *(Specify major items)*	
Total costs and expenses (lines e - l)	
Net income after foreign income taxes	
Unrealized profit or loss on books of parent organization resulting from exchange revaluation	
Net income after adjustment for exchange revaluation	

Table A2

1966 Values for S_{12}, S_{22}, S_{32}, S_{24}
(units are millions of local currency units)

	Chemicals			Electrical Machinery	
	Germany	Canada	Japan	Germany	Japan
Imports from U.S. (S_{12})	.710 E3	.443 E3	.772 E5	.438 E3	.301 E5
U.S. Subsidiary Production (S_{22})	.164 E4	.163 E4	.106 E6	.134 E4	.943 E4
Imports from 3rd Countries (S_{32})	.278 E4	.112 E3	.103 E6	.172 E4	.135 E5
Native Firm Production (S_{42})	.213 E5	.174 E3	.285 E7	.311 E5	.240 E7

Table A3

Canada Chemicals

Year	Firms	Employees	Wages & Salaries	Shipments	Value Added	Materials	Capital Stock	Cap. Stock Corr. for Utilization	Industry Selling Price Index of Chem. Prods. (1935-1939 = 100)	Average Weekly Wages & Salaries for Chem. & Chem. Product Workers	Price Index of Industrial Materials (1935-1939 = 100)
	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.
1957	1049.00	319353.	218136.	0.113440E 07	576084.	562314.	0.100200E 07	978199	182.3	79.29	240.3
1958	1045.00	319592.	231088.	0.123347E 07	643586.	598649.	0.113000E 07	1124050	183.0	83.42	229.8
1959	1042.00	319914.	239126.	0.131015E 07	676992.	635130.	0.122000E 07	1206330	187.0	86.70	240.2
1960	1063.00	321166.	251909.	0.135769E 07	728462.	641394.	0.130700E 07	1249690	188.2	90.92	240.4
1961	1067.00	311187.	254004.	0.143575E 07	763747.	677684.	0.141365E 07	1300920	188.7	94.93	243.2
1962	1080.00	312374.	260249.	0.154359E 07	825105.	722370.	0.151550E 07	1426410	190.5	98.57	248.0
1963	1093.00	320283.	272106.	0.164479E 07	870646.	779606.	0.161250E 07	1506940	189.3	101.60	253.5
1964	1140.00	329977.	300047.	0.179807E 07	949649.	861493.	0.172865E 07	1644560	191.2	105.03	258.3
1965	1118.00	346608.	336913.	0.197332E 07	0.103548E 07	958152.	0.191905E 07	1870070	200.2	108.45	258.7
1966	1152.00	359958.	359958.	0.217420E 07	0.112958E 07	0.106516E 07	0.216545E 07	2169640	207.1	114.71	261.4
1967	1142.00	370845.	389557.	0.226877E 07	0.119356E 07	0.109652E 07	0.240070E 07	2342640	216.6	121.70	253.1
1968	1124.00	377758.	428562.	0.242860E 07	0.128502E 07	0.114964E 07	0.264785E 07	2577370	213.7	129.49	254.0

Sources:

1. Dominion Bureau of Statistics, "Manufacturing Industries of Canada".
2. Dominion Bureau of Statistics, "Prices and Price Indices".
3. Dominion Bureau of Statistics, "Canadian Statistical Review".
4. Dominion Bureau of Statistics, "Fixed Capital Flows and Stocks, Manufacturing".
5. Dominion Bureau of Statistics, "Public and Private Investment in Canada".

Notes:

A. Source 1.
B. Source 1. Entries represent the number of employees. See text for construction of series.
C. Source 1. In thousands of Canadian dollars. See text for construction of series.
D. Source 1. Calculated value of production plus net inventory accumulation. In thousands of Canadian dollars
E. Source 1. In thousands. 1957 figure constructed as in text.
F. Source 1. Constructed as the sum of materials used plus fuels and electricity. In thousands.
G. Source 4.&5. In thousands. Constructed as in text from capital stock in source 4 and investment data in source 5.
H. Capital stock multiplied by utilization rate. In thousands.
I. Source 2. In estimations base was changed to 1966.
J. Source 3. An index of wages was constructed from this series with the base being 1966.
K. Source 2. Base changed to 1966.

Table A4 JAPAN

CHEMICAL INDUSTRY

CURRENCY IN MILLIONS OF YEN

SIZE GROUP	YEAR	FIRMS	EMPLOYEES	WAGES	GROSS OUTPUT	MATERIALS	VALUE ADDED	FIXED ASSETS NET BOOK VALUE OPENING	CLOSING	DEPRECIATION	AVGE. WAGES PER MONTH
8 (500-999)	1963	98	67693	32248.5	394371.4	231362.3	137273.5	162927.3	178117.4	25037.4	26.6
	1964	109	75848	37702.6	494504.9	272428.6	188698.7	191285.9	224137.8	30798.8	28.9
	1965	104	73701	40647.1	531195.0	283404.9	213047.4	198714.3	215425.3	32308.2	30.8
	1966	104	72086	47729.2	590162.7	328615.0	223680.8	227089.0	234843.7	35431.6	34.7
	1967	109	76284	53638.3	667330.6	328060.0	294511.6	241825.7	297220.0	42318.9	38.4
	1968	113	78133	62113.9	810656.5	394257.9	366690.0	292945.9	328937.9	47184.4	43.6
	1969	118	80529	73436.9	929605.4	424755.0	451107.9	323423.1	363874.6	50518.6	46.0
9 (1000+)	1963	82	180293	89269.1	834295.8	407396.1	356766.4	382010.0	418807.8	67206.9	29.3
	1964	84	183987	99098.5	996228.6	486342.3	423062.5	425512.0	488915.9	84145.1	31.6
	1965	81	179805	102848.7	1035157.6	508492.0	420499.7	510565.9	564965.2	101745.3	35.2
	1966	81	167935	111565.4	1140036.5	546617.1	484284.8	556102.6	546411.5	104862.2	38.5
	1967	81	166264	123078.3	1309265.6	598843.3	600343.9	555691.2	567998.8	106602.8	42.9
	1968	83	166626	141548.0	1464900.6	682769.1	662949.7	580076.3	648060.6	115184.6	45.2
	1969	86	167443	167101.6	1789602.9	790021.2	864225.6	667181.7	739384.8	130406.4	48.0
TOTAL	1963	7531	486829	212496.3	2193490.0	1214187.8	840215.9	824218.8	929443.1	132905.4	27.5
	1964	7291	501928	240335.6	2604543.7	1438795.4	991852.2	952208.0	1106864.7	166427.3	29.6
	1965	7160	499044	260315.7	2822102.8	1562550.7	1052266.1	1123612.2	1247921.4	198165.4	33.1
	1966	7222	489212	292480.2	3197949.4	1761365.9	1217075.5	1273355.0	1295776.3	210739.6	36.3
	1967	6147	480952	319057.7	3522153.9	1807069.7	1483829.8	1261923.1	1368106.6	223334.0	40.1
	1968	6040	486073	368101.0	4084451.9	2092633.9	1729388.7	1389791.0	1593967.3	253686.9	44.4
	1969	6313	493476	433836.8	4855789.8	2370095.5	2187278.1	1594575.4	1836948.5	286366.2	47.2

YEAR	INDIRECT TAXES g/	CHEMICAL PRODUCTS PRICE INDEX	INDUSTRIAL RAW MATERIALS PRICE INDEX h/	CAPACITY UTILIZATION h/
1963	6150.0	101.0	92.2	0.9075
1964	7427.8	102.4	93.5	0.9222
1965	9028.9	103.0	93.9	0.8452
1966	8705.0	100.0	100.0	0.8397
1967	7878.2	98.6	103.0	0.8834
1968	8703.6	[illegible]6	[illegible]04.3	0.9147
1969	11987.7	[illegible]5	[illegible]07.5	0.9408

Sources

1/ Census of Manufactures. Report by Industries, Research and Statistics Division Ministry of International Trade and Industry. Annual, in Japanese. (all data except indices).

2/ Monthly Statistics of Japan Bureau of Statistics. Office of Prime Minister.

3/ Unpublished data supplied by Donald Curtis of U.S. Treasury Department.

Footnotes

a/ The size groups are classified according to the number of employees per firm. The figures below the size group number give the range.

b/ The full heading is 'Wages and salaries in cash and kind'

c/ Fuels and electricity are included.

d/ Value added = gross output - materials - depreciation - indirect taxes.

e/ These figures are net of assets under construction. As reported in Japanese industry revalues its assets annually.

f/ All [illegible] and 1969 figures and the 1968 TOTAL figures are estimated. It should be noted that until 1968 there were 5 classifications but since 1968 there are only 3.

g/ Indirect taxes are given in total only. The figures for each size group can be found by appropriate manipulation of the definition of Value Added in d/ above.

h/ These indices are not specifically for the Chemical Industry.

Table A5 West Germany

Chemical a/

Currency in Millions of Deutshe Marks

Year	Firms	Wages	Personal Expenses Legal b/	Gross Output	Materials	Fixed Assets Closing Net Book Value	Chemical Products Price Index c/	Index Wages Per Man Hour d/	Capacity Utilization 2/
1957	84	1721.0	170.4	7150.0 e/	3464.4 e/	4668.9	103.7	46.9	0.9076
1958	88	1947.6	201.5	8480.0 e/	4113.9 e/	5556.5	102.5	49.9	0.8853
1959	81	1919.1	196.1	8515.0 e/	4130.1 e/	5631.2	101.5	52.9	0.8937
1960	81	2267.9	222.0	17700.0 e/	8580.0 e/	6417.0	100.9	57.9	0.9422
1961	75	2705.7	250.1	20980.7	10215.4	7597.3	99.7	65.7	0.9524
1962	84	3441.7	316.9	26379.7	12935.1	9244.7	98.4	72.3	0.9365
1963	91	3789.1	350.8	28023.6	13306.6	10111.4	97.0	79.0	0.9126
1964	82	4011.0	356.8	26924.0	12445.4	9883.0	97.1	85.8	0.9361
1965	85	4710.7	401.6	33143.7	15092.5	12340.6	100.4	93.2	0.9323
1966	81	4360.5	391.8	32564.9	15182.7	12271.0	100.0	100.0	0.8990
1967	80	5315.2	473.0	38560.0	17078.5	14798.7	98.8	104.8	0.8293
1968	64	5321.5	502.5	40694.0	18156.2	14394.5	102.7	110.0	0.8803
1969	72	6365.1	623.3	45586.5	20424.3	16054.1	101.5	120.0	0.9417
1970	65	7509.7	733.4	47675.8	21542.7	17374.7	102.7	138.9	0.9476

Sources:

1/ Wirtschaft und Statistik. Statistiches Bundesamt, Weisbaden. W. Kohlhammer GmbH., Stuttgart und Mainz. - various issues (In German)

2/ Unpublished data supplied by Donald Curtis, U.S. Treasury Department.

Footnotes:

a/ This includes the basic chemical industry (Chemische Industrie-German classification number 200), chemical fibres (Herstellung von Chemiefasern - 2004) and Mineral Oil (Mineralolverarbeitung - 205). The classification numbers refer to the 1962-66 period.

b/ Voluntary personnel expenses are estimated to be the same as the legal personnel expenses and are therefore not shown separately.

c/ This is an index of producers prices for industrial products.

d/ This index is for wages in the basic chemical industry. Indices for wages in the Chemical Fibres and Mineral Oil industries are also available.

e/ For the period 1957-59 gross output and Materials are estimated from gross profit i.e. output minus Materials. The 1960 estimates are based on figures given for a smaller number of firms as no gross profit figure is available.

Table A6 United States

Chemicals

Currency in Thousands of U.S. Dollars

Year	Employees[1]	Payroll[1]	Shipments[1]	Value Added[1]	Cost of Materials[1]	Gross Book Value of Depreciable Assets[1]	Wholesale Price Index of Chemical and Allied Prod. (1957-9 = 100)[2]	Chemical Worker Average Hourly Earnings (In Dollars)[3]	Potential Output
1958	699463	3948755.	23140000.	12273180.	10829200.	13639200.	100.4	2.29	25000000.
1959	717810	4232636.	26295000.	14281620.	12305950.	14498600.	100.0	2.40	26600000.
1960	723121	4414121.	26618000.	14347470.	12468600.	15636500.	100.2	2.50	28200000.
1961	712660	4523490.	27242080.	14752060.	12544120.	16965200.	99.1	2.58	30000000.
1962	727452	4757355.	29345360.	16062140.	13400270.	18162300.	97.5	2.65	32000000.
1963	737428	4964642.	31601150.	17443080.	14219020.	19307100.	96.3	2.72	34200000.
1964	749156	5244299.	34268090.	19165770.	15218420.	20736300.	96.7	2.80	36300000.
1965	780265	5594401.	37478760.	20955640.	16805450.	22991290.	97.4	2.89	38600000.
1966	822354	6129212	40780350.	22655560.	18516830.	25624890.	97.8	2.99	41000000.
1967	841400	6443000.	42148300.	23550090.	19250400.	28293400.	98.4	3.10	43500000.
1968	856300	6938500.	45622400.	25810400.	19984000.	30144090.	98.2	3.20	46300000.
1969	882900	7585000.	48164600.	27176700.	21138300.	32031800.	98.3	3.30	49500000.

[1] Source: Bureau of the census "Annual Survey of Manufacturers" or in census years "Census of Manufacturers".
[2] Source: Bureau of Labor Statistics "Monthly Labor Review".
[3] Source: Bureau of Labor Statistics "Employment and Earning Statistics - U.S.".

Table A7 JAPAN

ELECTRICAL MACHINERY

CURRENCY IN MILLIONS OF YEN

SIZE GROUP	YEAR	FIRMS	EMPLOYEES	WAGES	GROSS OUTPUT	MATERIALS	VALUE ADDED	FIXED ASSETS NET BOOK VALUE OPENING	FIXED ASSETS NET BOOK VALUE CLOSING	DEPRECIATION	AVGE. WAGES PER MONTH (000's YEN)
8 (500-999)	1963	116	82830	26391.0	218571.6	126424.4	79847.3	49118.4	62134.9	7036.1	19.8
	1964	115	82312	30438.9	254985.9	152458.5	86965.6	56143.7	60742.0	9042.3	22.1
	1965	123	84181	34579.5	285607.8	162129.6	108164.7	74728.0	73451.9	11062.8	24.1
	1966	140	98677	42785.5	352372.5	200270.5	136061.8	72380.3	76917.9	10581.4	27.3
	1967	146	103375	49160.5	439154.9	252957.9	167550.8	60523.4	75600.6	11813.9	28.2
	1968	165	117059	68502.3	573479.5	327173.1	224908.1	79067.3	90207.1	14516.7	34.9
	1969	193	133181	83934.7	764148.0	402052.1	271280.9	85982.1	111409.7	17757.8	38.6
9 (1000+)	1963	126	332152	117829.0	1092119.7	577364.3	437770.6	269532.2	287876.4	38196.7	21.9
	1964	144	364200	141369.2	1325503.1	728169.7	507922.0	299417.5	305639.1	48480.8	23.7
	1965	136	332355	144252.4	1178296.4	651016.1	450248.4	291991.7	292285.1	46755.6	26.3
	1966	144	345995	162267.1	1371597.8	764757.3	530596.3	297685.1	292025.3	48093.8	29.1
	1967	159	391981	219797.0	1931336.7	1061741.5	779862.9	321569.8	344985.8	57396.2	33.4
	1968	171	424825	279468.8	2525439.3	1415705.3	992840.6	351824.7	407948.9	69110.6	37.3
	1969	200	469524	351217.3	3258706.2	1865441.5	1283159.8	408357.9	485718.2	90770.5	41.0
TOTAL	1963	14466	852927	268011.4	1995464.0	1092662.6	797745.2	429610.6	476795.5 i/	60890.2 i/	21.0
	1964	14333	893189	314084.4	2398080.3	1365624.2	906005.7	483667.8	512818.7	76051.3	22.9
	1965	14285	851454	332912.5	2302299.7	1305988.3	880944.9	510340.9	518523.0	78611.5	25.4
	1966	16300	926460	383322.7	2738406.0	1567207.4	1056644.0	521847.9	532394.5	79522.7	28.0
	1967	17312	1011237	485952.7	3697187.2	2093213.3	1467233.7	554261.8	620239.0	95617.8	31.6
	1968	18568	1100386	611049.1	4714503.5	2702433.1	1840483.2	630175.3	730700.5	115316.4	36.0
	1969	22662	1268242	780446.9	6135906.6	3550965.3	2363336.0	736242.1	902870.4	148034.7	39.5

YEAR	INDIRECT TAXES g/	ELECTRICAL PRODUCTS PRICE INDEX	INDUSTRIAL RAW MATERIALS PRICE INDEX h/	CAPACITY UTILIZATION h/
1963	44151.1	100.7	92.2	0.9075
1964	50393.1	100.7	93.5	0.9222
1965	36743.3	99.6	93.9	0.8452
1966	35031.8	100.0	100.0	0.8397
1967	41122.3	100.5	103.0	0.8834
1968	56269.8	100.7	104.3	0.9147
1969	73566.4	100.6	107.5	0.9408

Sources

1/ Census of Manufactures. Report by Industries, Research and Statistics Division Ministry of International Trade and Industry. Annual, in Japanese. (all data except indices).

2/ Monthly Statistics of Japan Bureau of Statistics. Office of Prime Minister.

3/ Unpublished data supplied by Donald Curtis of U.S. Treasury Department.

Footnotes

a/ The size groups are classified according to the number of employees per firm. The figures below the size group number give the range.

b/ The full heading is 'Wages and salaries in cash and kind'

c/ Fuels and electricity are included.

d/ Value added = gross output - materials - depreciation - indirect taxes.

e/ These figures are net of assets under construction. As reported in Japanese industry revalues its assets annually.

f/ All 1963 and 1969 figures and the 1968 TOTAL figures are estimated. It should be noted that until 1968 there were 5 classifications but since 1968 there are only 3.

g/ Indirect taxes are given in total only. The figures for each size group can be found by appropriate manipulation of the definition of Value Added in d/ above.

h/ These indices are not specifically for the Electrical Machinery Industry.

i/ According to the sub-group totals these figures should be 478,079.2 and 59,605.6 respectively. The absolute difference, subject to minor round-off variations, is 1284.0 in both cases. This is the only case in which the sub group figures do not add up to the TOTAL figure.

Table A8

West Germany

Electrical Machinery a/

Currency in Millions of Deutshe Marks

Year	Firms	Wages	Personnel Expenses Legal	Personnel Expenses Voluntary b/	Gross Output	Materials	Fixed Assets Closing Net Book Value	Electrical Products Price Index	Index Wages Per Man Hours	Capacity Utilization 2/
1957	47	1721.5	177.8	53.3	5400.0 c/	2757.9 c/	1204.1	93.7	48.1	0.9076
1958	52	1942.6	214.7	64.4	6000.0 c/	3078.6 c/	1316.1	93.7 d/	51.2	0.8853
1959	49	2086.5	233.1	68.1	6300.0 c/	3230.9 c/	1394.8	93.5	53.8	0.8937
1960	46	2435.2	259.8	133.8	8570.0 c/	4506.0 c/	1500.1	93.7	59.0	0.9422
1961	43	2837.6	287.5	153.8	10253.0	5281.8	1813.4	94.6	64.5	0.9524
1962	42	3266.5	317.5	174.9	11128.3	5554.5	2122.4	95.6	73.0	0.9365
1963	52	3802.0	378.0	208.7	12744.4	6286.8	2513.3	95.1	77.6	0.9126
1964	53	3982.2	376.0	235.8	13798.8	6916.7	2547.1	95.8	85.4	0.9361
1965	49	4437.5	410.4	252.4	14896.6	7479.3	2514.0	98.2	93.5	0.9323
1966	40	4823.8	452.4	255.6	15533.3	6922.7	2630.2	100.0	100.0	0.8990
1967	35	5111.4	479.4	237.3	15735.4	6894.1	2987.3	97.4	104.4	0.8293
1968	30	4868.7	491.7	238.5	15655.0	6965.4	2785.0 e/	101.2	108.5	0.8803
1969	30	5420.0	580.4	299.5	18735.9	8917.9	2985.0 e/	103.6	119.4	0.9417
1970	32	6678.8	714.4	369.3	23744.9	12181.8	3371.3	110.2	133.1	0.9476

Sources:

1/ Statistisches Bundesamt Wiesbaden. Wirtschaft und Statistik W. Kohlhammer Stuttgant und Mainz. Various years. (In German)
2/ Unpublished data supplied by Donald Curtis, U.S. Treasury Department.

a/ Electrotechnik. German classification number 250 (was number 27 until 1962).
b/ Estimated from the relationship between legal and voluntary contributions for all manufacturing industry.
c/ For the period 1957-59. Gross output and Materials are estimated from gross profit i.e. output-minus materials. The 1960 estimates are based on figures given for a smaller number of firms. No gross profit figure is available.
d/ 1958-59 data comes from 2 series (1950 = 100 and 1958 = 100) that are not strictly comparable.
e/ The 1968 and 1969 figures are estimated based on various ratios in the 1965-70 period. The actual figures given in the source are 1,751.7 and 1,961.0.

Table A9

United States

Electrical Machinery

Currency in Thousands of U.S. Dollars

Year	Employees[1]	Payroll[1]	Shipments[1]	Value Added[1]	Cost of Materials[1]	Gross Book Value of Depreciable Assets[1]	Wholesale Price Index of Electrical Machinery[2] (1957-9 = 100)	Average Hourly Earnings (In Dollars)[3]	Potential Output
1958	1122284	5605985.	19008000.	10395360.	8766900.	4606359.	100.2	2.12	20600000.
1959	1248753	6558893.	22496000.	12526700.	10314000.	5195919.	101.7	2.20	22500000.
1960	1340272	7245204.	23593000.	13064030.	10607000.	5884271.	101.3	2.28	24500000.
1961	1367053	7709101.	24592200.	13701720.	10983670.	6574542.	100.0	2.35	26600000.
1962	1463041	8545471.	27589080.	15594140.	12310690.	7285914.	98.4	2.40	28900000.
1963	1511819	9284279.	29840170.	17010670.	12942640.	7804793.	97.4	2.46	31500000.
1964	1483773	9407335.	30874670.	17765390.	13233960.	8314671.	96.8	2.51	34300000.
1965	1604788	10449510.	35127260.	20161720.	15430730.	9237500.	96.8	2.58	37500000.
1966	1810989	11988110.	40842600.	23481680.	18472600.	10462500.	99.0	2.65	40900000.
1967	1874900	12968000.	43361000.	24487290.	19397100.	11819700.	101.8	2.77	44500000.
1968	1882700	13807800.	46470400.	26425000.	20321600.	12810700.	103.1	2.88	48500000.
1969	1915900	14791800.	49119600.	28275100.	21141100.	13800000.	104.8	2.99	53000000.

1 Source: Bureau of the Census "Annual Survey of Manufacturers" or in census years "U.S. Census of Manufacturers"
2 Source: Bureau of Labor Statistics "Monthly Labor Review".
3 Source: Bureau of Labor Statistics "Employment and Earning Statistics - United States".

Footnotes

[1] Compare, for example, the contrasting views of Benoit [5] and Barber [4].

[2] An exception to this rule is Branson [6].

[3] This assumption of partial substitutability admits the claim made by industry that goods manufactured abroad by American and native firms may be specially designed for local markets. This "local model" thesis however, may not be as plausible for chemicals as it is for electrical machinery. The unlikely possibility of complementarity between pairs of product aggregates as large as the ones we deal with can be incorporated via negative cross-elasticities.

[4] Stevens [16] has shown that a world-wide profit-maximization model served better to explain the direct investment activities of U.S. MNC's than several alternative hypotheses. Horst [11] also adopts this behavioral assumption. In analyses of domestic investment it is customary to make the model operational by asserting that the firm maximizes the present value of its cash flow = $\int (pQ - wL - qI - rB + dB/dt)e^{-rt}dt$ subject to a production function constraint. Assuming that market parameters are independent of the firm's investment rate and given perfect capital markets so that r is constant and dB/dt - rB drop out, the objective reduces to the myopic maximization of profits during each period with respect to labor, capital and price where profits = $pQ - wL - K(r + d - \dot{q}/q)$. Stevens [17] has recently shown that under uncertainty, somewhat similar expressions, including means and covariances of random variables, can be substituted for these hypothetical objectives. In the context of the MNC, Adler [1] has argued that the perfect capital market assumption is equivalent to assuming that exchange-risk can be hedged costlessly, no constraints on money-capital flows and that stockholders all reside in one country. Under certainty, restrictions on capital flows can be incorporated in the form of a money capital constraint on the financing of the FS. Under uncertainty they produce an optimal foreign investment decision after which global maximization can proceed. These nuances of imperfect markets are omitted below.

[5] The possibility that the FS. produces for export to the U.S. or third countries merely produces analytical complexity without additional insight. It is therefore omitted for convenience.

[6] Cf. Henderson and Quandt [10], p. 182 and Allen [3], p.359.

[7] Cournot duopoly reaction equations could be specified by solving (7a), (7b) and (7c) for S_{22} in terms of S_{42} and (9) for S_{42} as a function of S_{22}. We omit this exercise because it adds nothing to our investigation. In particular, such reaction equations would not serve to identify or illuminate the alternative position.

[8] An analysis of the requirements for the dynamic stability of the system can probably determine the sign of the determinant, particularly since we assume that the goods in this market are gross substitutes, a case for which many theorems on dynamic stability exist (see, e.g., Quirk and Soposnik [19], pp. 210-215). In fact, in all relevant cases the sign of the 6x6 determinant turned out to be positive, the sign required by Metzler's theorem on stability.

However, we are reluctant to assert that the determinant of the market matrix must be positive without considerable further analysis. Since our system is one of imperfect competitors it cannot immediately be analyzed out of equilibrium in terms of excess demand functions. Second, the usual procedure for a dynamic analysis is to assume prices as the independent variables; we have taken the alternative route making quantities the independent variables, thus necessitating a transformation of our system or the available stability theorems.

[9] For example, if returns to scale are diminishing at the margin, $C_1'' > 0$. An increase in S_{22} will reduce S_{12} and also cause marginal production costs, C_1', to fall. S_{11} must therefore rise in order to maintain $R_1'' = C_1'$ as is required. The case of increasing returns to scale is symmetric.

[10] Theoretically it is not difficult to introduce an input into the production of S_{22} exported from the home country--perhaps part of the production of $Q_1 = S_{11} + S_{12}$. Then the total export effect of direct investment becomes the sum of the intermediate effect and our export displacement effect.

It has been impossible for us to separate exports from the U.S. in our industries into intermediates to subsidiaries and other sales; therefore we have attributed all exports to S_{12}, sales to unaffiliated parties. Naturally, for precise estimates of the various effects we seek it is necessary to separate U.S. exports and materials inputs for subsidiaries into their components.

[11] We would like to reiterate our gratefulness to the people at BEA who supported and implemented the idea to develop a system which made research possible while preserving the confidentiality of the underlying data. Dave Devlin, formerly Assistant Director for International Economic Analysis, played the major role in promoting the System. Arnold Gilbert has done and is doing an excellent job in developing the necessary computer programs and is overseeing the completion of the actual research projects.

[12] Total market sales were obtained from the sources indicated in the Appendix for each country table. Foreign subsidiary sales are preliminary figures obtained from the Bureau of Economic Analysis.

[13] There is a possible third justification for our preference. Our data do not distinguish between raw materials and processed or manufactured inputs. The latter may substitute for labor and capital. Consider a refrigerator manufacturer. If outside suppliers deliver his sealed motors, they will substitute for the labor and capital that would otherwise have had to be used in their own manufacture. Further, manufactured inputs can be used in varying proportions: outside suppliers could provide shelves and racks as well. In short, one would expect the coefficients of labor and capital to add to less than one in this case. However, this would not be evidence of declining returns to scale. Stevens wishes to disassociate himself from this footnote since the cases where materials can be validly excluded from the regression need have nothing to do with the degree to which they have been processed.

[14]The measure of purchased inputs, referred to above as materials was constructed in two alternative ways, both of which led to virtually identical results. A measure of "costs of goods and services purchased" was collected directly in the 1966 Census. Since the instructions to this entry were somewhat ambiguous, we also measured purchased inputs directly as a measure of output minus value added. The latter performed consistently, but marginally, better in terms of R^2 and t-ratios, so it was used in the "best" regressions.

[15]See, e.g., Walters [18].

[16]These, of course, are equal for constant returns to scale.

[17]Since none of the production functions estimated with native firm data was uniformly superior to the others, one of the criteria used to choose the best production function was its ability to explain 1966 costs with reasonable values of the cost of capital. For the foreign subsidiary sample, the best production function also turned out to explain sample costs the best, in terms of the average error of prediction for the sample.

[19]Jorgenson [13].

[20]Hall and Jorgenson [9].

[21]Coen [7], p. 184

[22]Perfect capital market models such as Lintner's [14] can be extended to the international setting by including exchange risk which produces the equivalent of heterogeneous expectations. Theoretically, the MNC's cost of capital will then be invariant to financial decisions which do not introduce any risk of default. The cost of capital will not, however, be invariant to investment decisions which change the firm's systematic risk, a nebulous concept which cannot be measured with ex post data when expectations are not homogeneous. In the face of these difficulties and in the absence of appropriate data, we are forced to rely on others' estimates.

[23]The S_{i2} were measured as values in constant 1966 prices. It should be clear that P_{12} and P_{32} are merely proxies for the relevant prices, i.e., the local selling price of U.S. and other countries' exports. These latter, of course, were unavailable. Further, national income is a proxy for the relevant activity variable: owing to multicollinearity we chose not to employ total local consumption, i.e., total sales-exports. S_{t2} was corrected for exports and therefore represents total local output for local use. Sources of quantity and income data are given in the Appendix. Price data and trade weights were provided by Helen Junz.

The inadequacies of data availability, e.g., short time-series and high levels of aggregation further prevented any attempt to estimate the demand functions as a system. Consequently, the regression for each product was run independently, without constraints on the coefficients.

[24]We can express the price cross elasticities, $\partial S_i/\partial p_j$, in terms of the Slutsky compensated price elasticities, $\partial f_i/\partial p_j \equiv \partial f_j/\partial p_i$, and income elasticities:
$\partial S_i/\partial p_j = \partial f_i/\partial p_j + S_j \partial S_i/\partial Y = \partial f_i/\partial p_j - S_j S_i a_{i4}/Y$ when S_i is defined as in the text. It then follows for $i \neq j$, $\partial S_j/\partial p_i = \partial S_i/\partial p_j + S_i S_j (a_{j4} - a_{i4})/Y$. The cross elasticities will differ if the income elasticities differ. The size of the difference will also depend on $S_i S_j/Y$. For large product groups such as ours, this quantity may not be less than 1.

[25]Since the likelihood of multicollinearity in the inverse demand function is so very high, it is not a useful empirical specification.

[26]Howard Howe pointed out to us that these results could be the outcome of capacity constraints in the foreign markets. In the face of such constraints, measured price elasticities would appear to be low while income elasticities especially for imports might appear to exceed 1 owing to scarcity. While this explanation seems plausible it is unsuitable, for our model assumes that "normal conditions" prevail. In addition, however, many other problems plague our demand estimates. Data deficiencies have already been mentioned. Moreover, there may be errors of specification. Clearly, fruitful work remains to be done in this area.

[27]See, e.g., Samuelson [15], p. 63 ff.

[28]Positivity of dS_{42}/dS_{22} may result in a scenario such as the following. The rise in S_{22} will produce decreases in R'_{22} and P_{22}. The price of S_{42} must then decline merely to maintain S_{22} at a constant equilibrium level. If, however, the result of relaxing the constraint on S_{22} is to reduce the MNC's optimal exports, S_{12}, then P_{12} will rise. Erstwhile customers of S_{12} will then turn to S_{42}, the equilibrium level of which will also rise. The net effect of these offsetting forces leaves the sign of dS_{42}/dS_{22} generally ambiguous.

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