Transnationals and Foreign Trade: Evidence from Brazil

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A recursive model of exports and imports of manufactures, in which imports depend in part on exports, is estimated using data for a cross-section of 17,053 industrial firms. In this sample, 652 firms are foreign-owned. Explanatory variables include firm size, skill intensity, advertising and other variables in addition to foreign ownership. Foreign ownership has a large, independent effect on both export performance and import propensities, but foreign ownership in itself explains little of the relatively low export/import ratios registered by affiliates of transnationals.

1. INTRODUCTION

Previous studies [*Willmore, 1985; 1986*] have found transnational firms operating in Brazil's manufacturing sector to account for a disproportionate share of exports and to export more than otherwise comparable Brazilian firms. The present study continues this line of research by examining import propensities as well as export performance in a clearly defined model of foreign trade at the level of the firm.

This article draws on industrial product tax (IPI) data for 17,053 firms that operated manufacturing plants in Brazil during the year 1980. More than a quarter of these firms registered direct exports or imports of manufactures in 1980. Exports of manufactures by firms in the sample total approximately $6.6 billion, equal to a third of all exports of goods and more than two-thirds of all exports of manufactures in the year 1980. The same firms imported manufactured goods in the amount of $4.9 billion, leaving net exports of manufacturers of $1.7 billion and an export/import ratio of 1.29. Imports include capital goods and finished

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products imported for resale, but most are manufactured inputs used in the production process.

It was possible to identify 652 of the sample firms as foreign-owned, defining foreign-owned as firms in which 10 per cent or more of the voting stock is held directly or indirectly by non-residents. Ownership information was obtained by crossing IPI data with corporate income tax information and with published balance sheet data.[1] Only 17 firms are publicly-owned; the remaining 16,384 firms are privately-owned by residents of Brazil. The 652 affiliates of transnational enterprises account for 36 per cent of the exports and 40 per cent of the imports of the sample firms. As a consequence, the export/import ratio for foreign firms is only 1.16, compared to 1.97 for privately-owned domestic firms and 1.29 for the sample as a whole. State enterprises are net importers of manufactures and have an export/import ratio of 0.27.

At this point it should be emphasised that a high export/import ratio is not proof of a positive effect on Brazil's trade balance, for indirect imports (the imports embodied in locally purchased goods) and imports of raw materials are excluded from these calculations. Nor does a ratio lower than unity necessarily imply a negative effect on the trade balance, for no account is taken of import substitution. It is quite possible for a firm to produce behind a high protective tariff, fail to export any of its output, import capital equipment and intermediate goods, yet, by displacing imports, have a positive effect on the balance of trade.

Since transnational enterprises, by definition, have links to other countries, it is not surprising that they take advantage of such links both to import and to export when it is profitable to do so.[2] But to what extent are the high trade propensities and the low export/import ratios of transnationals the result of foreign ownership *per se* and to what extent are they the result of size, type of industry or other characteristics of foreign firms that differ from those of domestic firms? I attempt to answer this question by specifying and estimating a model of foreign trade in which foreign ownership enters each equation explicitly as a firm-specific dummy variable. As a by-product of this exercise, the model also describes the effect of other explanatory variables, such as size, skill intensity and advertising on the foreign trade of individual firms in Brazil's manufacturing sector.

II. A RECURSIVE MODEL OF FOREIGN TRADE

The model to be estimated consists of four equations with four endogenous variables: X, a dichotomous variable that takes the value of 1 if a firm exports, and zero otherwise; M, another dichotomous variable that

takes the value of 1 if a firm is an importer, and zero otherwise; LOGX, the logarithm of the value of exports; and LOGM, the logarithm of the value of imports. Z is a matrix of n observations for k explanatory variables. One column of Z corresponds to a dichotomous variable for foreign ownership that takes the value 1 if a firm is foreign-owned and zero otherwise. Z_x and Z_m are sub-matrices of Z that contain observations for those firms that export and those that import, respectively.

The first equation of the model states that X is equal to the probability of exporting plus an error term:

$$X = Pr(X=1) + u_1. \tag{1.1}$$

The underlying probabilities are not observed. What is observed are the two values taken by X: 1, the occurrence of which has a probability of PR(X=1), and 0, the occurrence of which has a probability of 1–Pr(X=1). The error (u_1) is equal to X-Pr(X=1): when X=1, u_1=1–Pr(X=1); when X=0, u_1=-Pr(X=1). As a consequence, the equation is intrinsically heteroscedastic: probabilities close to 0 or 1 have small errors whereas those close to 0.5 have large errors. In order to obtain efficient estimates of the parameters and, more importantly, unbiased estimates of their variance, it is necessary to use the technique of weighted least squares, the weight for each observation being the reciprocal of [Pr(X=1)]*[1–Pr(X=1)].

To estimate the first equation one must first specify the function Pr(X=1). The approach followed here is to express the probability of exporting as a cumulative logistic function, namely.

$$Pr(X=1) = 1 / [1 + \exp(-Zb_1)] \tag{1.2}$$

where b_1 is a kxl column vector of parameters, some of which are set equal to zero by assumption. This specification, which is known as a logit regression, restricts the estimated probabilities to the zero-one interval and assumes that a change in an explanatory variable has its greatest impact where the probability of exporting is 50 per cent (see Pindyck and Rubinfeld [*1981: 287–300*]).

The second equation expresses M as the probability of importing given the value of X (i.e. given whether or not a firm exports) plus an error term:

$$M = Pr(M=1|X) + u_2. \tag{2.1}$$

This equation is also heteroscedastic, so weighted least squares are

required for efficient parameter estimates and unbiased estimates of their variance. The probability of importing is assumed to follow a cumulative logistic function of the type

$$\Pr(M=1|X) = 1/[1 + \exp(-Zb_2 - a_2X)],\ a2>0\ , \qquad (2.2)$$

where a_2 is a single parameter and b_2 is another kxl column vector of parameters. Note that export activity is expected to have a direct, positive effect on the probability of importing.

The third equation of the model is estimated by applying ordinary least squares (OLS) to data for the subset of firms that export:

$$(LOGX|X=1) = Z_x b_3 + u_3. \qquad (3.0)$$

The error term (u_3) is a random disturbance with zero mean and constant variance. A zero restriction is imposed on some elements of b_3, the kxl column vector of parameters.

For the fourth and last equation it is necessary to measure exports in such a way that the minimum value of LOGX is greater than zero for X=1 and to define LOGX=0 for all X=0:

$$(LOGM|M=1,X,LOGX) = Z_m b_4 + a_4X + c_4LOGX + u_4,\ c_4>0 \qquad (4.0)$$

The disturbance (u_4) is assumed to have zero mean and constant variance. LOGM depends on both X and LOGX, but the coefficient of X can take any sign while that of LOGX is expected to be positive.

III. DATA AND VARIABLES

Table 1 reports the mean and standard deviation of four endogenous and 12 exogenous variables for the total sample, for the 3,764 exporters, and for the 2,826 importers. Only half of the exporters are direct importers whereas two-thirds of the importers also export. The first nine exogenous variables are firm-specific, that is, they vary from firm to firm within a given industry, whereas the last three variables are industry-specific, that is, they take the same value for all firms in an industry. Few firms are state-owned and few have research and development programmes, a fact true for Brazilian manufacturing in general as well as for this particular sample of firms. Each firm is assigned to a four-digit industry, which provides a large number of industry dummies in addition to the variables listed in Table 1. The industry-specific variables of course become

TABLE I

DESCRIPTION OF THE DATA

		Mean (standard deviation) TOTAL	EXPORTERS	IMPORTERS
Endogenous Variables:				
X	Dichotomous variable, 1 if firm exports, 0 otherwise.	0.221 (0.415)	1.000	0.664 (0.472)
M	Dichotomous variable, 1 if firm imports, 0 otherwise.	0.166 (0.372)	0.498 (0.500)	1.000
LOGX	Value of exports (cruzeiros) in natural logarithmic scale.	...	15.302 (2.803)	15.981[a]/ (2.830)
LOGM	Value of imports (cruzeiros) in natural logarithmic scale.	...	16.164[a]/ (2.341)	15.903 (2.298)
Exogenous Variables:				
FOR	Dichotomous variable, 1 if non-residents own 10% or more equity, 0 otherwise.	0.038 (0.192)	0.136 (0.342)	0.196 (0.397)
STATE	Dichotomous variable, 1 if publicly owned, 0 otherwise.	0.001 (0.032)	0.003 (0.054)	0.004 (0.065)
RD	Research and development, a dichotomous variable, 1 if program of R&D, 0 otherwise.	0.002 (0.048)	0.007 (0.084)	0.012 (0.107)
ADV	Advertising as a proportion of domestic sales, constrained to a maximum of 0.1.	0.005 (0.011)	0.008 (0.014)	0.009 (0.016)
LOGWAGE	Average annual wage (cruzeiros) in natural logarithmic scale.	12.130 (0.624)	12.406 (0.592)	12.595 (0.593)
LOGNWVA/L	Non-wage value added per employee (cruzeiros) in natural logarithmic scale.	11.172 (3.672)	12.084 (2.720)	12.385 (2.783)
LOGK/L	Fixed assets per employee (cruzeiros) in natural logarithmic scale.	12.720[b]/ (1.037)	12.697[c]/ (0.997)	12.769[d]/ (0.986)
LOGVA/Q	Ratio of value-added to output, in natural logarithmic scale.	-0.872 (0.590)	-0.835 (0.457)	-0.796 (0.462)
LOGVA	Value-added by the firm (cruzeiros) in natural logarithmic scale.	16.600 (1.810)	18.330 (1.572)	18.643 (1.552)

TABLE 1 (cont.)

		Mean (standard deviation) TOTAL	EXPORTERS	IMPORTERS
GEOCON	Geographic concentration of an industry's output, index that varies from 0 to 2.	0.939 (0.229)	1.008 (0.211)	1.022 (0.205)
NOMPROT	Nominal rate of protection for an industry.	0.179 (0.309)	0.215 (0.3490)	0.284 (0.364)
EFFPROT	Effective rate of protection for an industry.	0.551 (0.673)	0.657 (0.749)	0.779 (0.760)

Source: GEOCON – IBGE, 1980 Industrial Census; NOMPROT and EFFPROT – W.G. Tyler, 1985, 'Effective Incentives for Domestic Market Sales and Exports: A View of Anti-Export Biases and Commercial Policy in Brazil, 1980–81', *Journal of Development Economics*, Vol. 18, Nos. 2–3, pp. 219–42; X, M, LOGX and LOGM – Industrial Product Tax (IPI) tabulations for 1980; all other variables – Secretaria de Receita Federal, tax returns for 1980.

Note: Sample size = 17,053, including 3,764 exporters and 2,826 importers.
a/ 1,876 firms that both export of export.
b/ 3,194 firms/
c/ 1,825 firms.
d/ 1,594 firms.

redundant when a dummy variable is included for each of the four-digit industries.

Braga and Willmore [*1991*] found the existence of exports to be a highly significant, positive determinant of the existence of research and development expenditures (RD) in Brazilian firms. Causality could conceivably run the other way as well, so RD is entered as a variable to test for a positive effect on a firm's propensity to export. Similarly, RD is included in the import equations with an expected negative coefficient because firms with established programmes of research and development are more likely to adapt their production to utilise local inputs, reducing dependence on imports.

From Willmore [*1985*], I expect advertising intensity (ADV) to have a positive effect on exports. A theoretical explanation for this expectation is that advertising is associated with monopolistic competition, and firms in monopolistic competition have an incentive to export because they operate on the declining portion of their average cost curve. The Drèze [1960] hypothesis would predict the opposite: countries which are minor participants in international trade in manufactures are expected to specialise in standarised manufactures that compete primarily on the basis of price with little need for advertising. Neither hypothesis yields a prediction for the import equations.

The average wage (LOGWAGE) is a proxy for the skill intensity of a firm's production. Skilled labour is a relatively scarce factor of production in Brazil, so standard (Heckscher-Ohlin) trade theory predicts a negative coefficient for this variable in the export equations. A positive coefficient can be expected in the import equations to the extent that the skill intensity of a firm's production is correlated with the skill intensity of its imports of manufactures.

For a capital-poor country like Brazil, conventional trade theory predicts a negative relationship between capital intensity and exports, and a positive relationship between capital intensity and imports. In Willmore [*1985: 33, 44–7*], using data for the year 1978, I found physical capital intensity to have the predicted negative effect on the probability of exporting, but the effect on exports of exporters was strongly positive. The positive coefficient reflects correlation between capital intensity and scale economies: the greater the economies of scale in production, the greater the incentive to expand production through exports and reduce unit costs of production. Trade theory is useful in predicting whether or not a firm will export in the first instance, but, once the export decision has been made, it is of little help in explaining the *proportion* of output that is exported by a particular firm.

Capital intensity is notoriously difficult to measure, so two alternatives are used in the regressions: non-wage value-added per employee (LOGNWVA/L) and fixed assets per employee (LOGK/L). Data for the second variable are available only for 3,194 firms, and these tend to rank among the largest. No information is available by firm on the commodity composition of exports and imports, so the assumption is that factor proportions in total output is a good proxy for factor proportions in exports and imports.

The ratio of value-added to output (LOGVA/Q) is included as a crude indicator of vertical integration. A negative coefficient is expected for all four equations. A negative relationship is expected between exports and vertical integration, for the 'drawback' provision for duty-free importation of inputs used in the production of goods for export is more valuable the more a firm relies on outside suppliers, that is, the less vertically-integrated the firm [*Willmore, 1985: 16–17*]. On the import side, a vertically integrated firm can be expected to produce its own manufactured inputs rather than rely on imports.

Firm size, measured as the logarithm of value-added (LOGVA), is a particularly important control variable given the fact that exporters and importers are larger, on average, than firms which do not engage in international trade. A positive coefficient is expected for this variable in all four equations of the model.

The index of geographic concentration (GEOCON) is an indirect measure of the intrinsic 'tradability' of the output of an industry and is expected to have a positive coefficient. When the output of an industry is highly concentrated, hence widely traded, within Brazil it will also be widely traded in international markets in the absence of artificial trade barriers. GEOCON is thus a control variable: it controls for the fact that some industries produce products (for example, transistor radios) that are inherently more tradable than others (for example, bricks). The variable was calculated from 1980 census data as the sum of $|p_i - q_i|$ where p_i is the proportion of Brazil's adult population living in the ith state, q_i is the proportion of industry output accounted for by the ith state, and the summation is over 26 states and territories. The number of manufacturing industries total 195, based on the classification system of the Brazilian tax authority (Secretaria da Receita Federal) at the four-digit level.

In Brazil, import licenses restrict competing imports, so legal tariffs bear little relation to actual protection. For this reason both of the protection variables (NOMPROT and EFFPROT) are based on comparisons of domestic prices in Brazil with international prices. Nominal protection (NOMPROT) is expected to have a negative effect on exports because high domestic prices make domestic markets more attractive than export markets. Holding nominal protection and the ratio of value-added to output constant, effective protection (EFFPROT) is expected to have a positive effect on exports.[1] This occurs because effective protection is protection of value-added: holding the domestic price of the final product constant, higher effective protection implies lower domestic prices for intermediate inputs and raw materials and this makes Brazilian products more competitive in foreign markets.

With other things (namely NOMPROT and LOGVA/Q) equal, EFFPROT is actually an inverse proxy for the price of inputs. This is an unusual use of an an effective protection variable, but the logic can be shown with a hypothetical example. Suppose that product 1 and product 2 each sell for 140 in the domestic market and 100 abroad, implying a nominal protection of 40 per cent. In addition, each product requires purchases (at domestic prices) of 50 in raw materials and intermediate inputs, leaving a value-added of 90. Now, suppose that inputs for product 1 are purchased at world prices, so value-added at world prices is 50 and effective protection is 80 per cent. If the inputs for product 2 cost 40 at world prices, its value-added is 60 at world prices and the effective rate of protection is 50 per cent. In either case, exports will require price discrimination, that is, the lowering of prices for foreign purchasers; but product 1 is more apt to be exported than product 2, for the producer of the former (the product with higher effective protection) obtains inputs at

competitive prices and can reduce more easily his profit margin for export.

No particular relationship is predicted between imports and protection, for the import data refer largely to imports of inputs whereas the explanatory variables refer to protection of final goods. There is no reason a priori to expect any correlation between protection of final goods and protection of the manufactured inputs required for their production.

The data for NOMPROT and EFFPROT are drawn from direct price comparisons in 1980 and 1981, and are reported at a somewhat higher level of aggregation than the industry classification used in this study. In many cases a single value for NOMPROT or EFFPROT serves for several industries.

An unfortunate limitation of these data is the absence of information on export incentives granted to individual firms in the calendar year 1980. During 1980 the export tax credit (*credito premio*) was restricted to a small number of firms with government export agreements (BEFIEX). Subsidised loans and corporate income tax credits were given to a large number of exporters, but it was not possible to determine the importance of these incentives for individual firms.

IV. EMPIRICAL FINDINGS

The model divides nicely into two blocks. The first two equations estimate the probability of exporting and the probability of importing. The second two equations 'explain' variations in the exports of exporters and imports of importers. A solution for the full model requires multiplication of the export/import probabilities of the first block of equations by the value of exports and imports calculated from the second block.

1. Export/Import Probabilities

Estimation of the parameters of the first two equations of the model present two related problems. First, both equations are heteroscedastic; the variance of the residual is not constant but rather a function of the probability of exporting or importing. Secondly, the equations are intrinsically non-linear. The first problem calls for weighted least squares while the second calls for an iterative maximum-likelihood technique. Since the probabilities are estimated rather than observed, it is necessary to utilise in each iteration weights calculated from the previous iteration until the solutions converge. This technique of iteratively re-weighted least

squares works well in the sense that the iterations always converge, but it is costly in terms of computer time when there are a large number of parameters to be estimated. Because of constraint of computer time, dummy variables are entered at the two-digit level (21 industry groups) instead of the four-digit level (195 industries). This is less than ideal, but the industry-specific variables help to control inter-industry differences in trade propensities within each two-digit group of industries.

Table 2 reports the parameter estimates for each logit regression. The coefficient of FOR, the main variable of interest, is positive and highly significant in each equation. Foreign ownership increases the odds of exporting by 3.75 times and the odds of importing by 18 times.[4] A firm which would, under domestic private ownership, have a 50 per cent chance of exporting and a 50 per cent chance of importing will, under foreign ownership, have a 79 per cent chance of exporting and a 95 per cent chance of importing if all other variables remain unchanged.

In contrast with FOR, the coefficients of STATE are negative and not statistically significant in either equation. The coefficient of RD is also insignificant, indicating that the existence of an established programme of research and development has no significant effect on the probability that a firm will engage in export or import activities. On the other hand, Braga and Willmore [*1991*] have shown, with different data, that the act of exporting does have a positive and highly significant effect on the probability that a Brazilian firm engages in research and development.

The coefficient of ADV is positive and highly significant in each equation. This implies that firms producing highly advertised, hence highly differentiated, goods are more likely to participate in international trade than are firms producing standardised commodities. For the export equation, this result is consistent with the interpretation of advertising intensity as a proxy for monopolistic competition and it replicates the findings of Willmore [*1985: 34–7*].

Skill intensity, as measured by LOGWAGE, has a negative but very small effect on the probability of exporting and a positive, large and highly significant effect on the probability of importing. Both coefficients have the sign predicted by standard trade theory. In the export equation the coefficient of LOGWAGE is statistically significant only at the 6 per cent level in a one-tailed test (12 per cent level in a two-tailed test), whereas in the import equation the coefficient is significantly different from zero at the 1 per cent level.

Capital intensity has the negative coefficient predicted by standard theory for the export equation, but the coefficient is also negative in the import equation, an indication either that the Heckscher-Ohlin prediction for imports is wrong or that capital/labour ratios for the imports of a

firm are negatively correlated with those for the output of a firm. When the variable LOGK/L enters the equations in lieu of LOGNWVA/L, the coefficients retain their negative sign but lose statistical significance. These alternative specifications are not shown because of the drastic reduction in the number of observations when LOGK/L is used.

The coefficient of LOGVA/Q is negative as expected and highly significant in each equation. This implies that holding firm size and other variables constant, an increase in vertical integration is associated with a reduction in the probability that a firm will export or import manufactures.

Firm size is controlled by entering LOGVA and the square of LOGVA in each logit regression. In each equation, size has the expected positive effect over the relevant range of firm size, but the marginal effect of size on the odds of exporting declines as size increases whereas for importing the marginal effect increases with size. For the average exporter (LOGVA=18.33), the derivatives of LOGVA in equations (1) and (2) of Table 2 are very similar: 0.9 and 1.0 respectively. For small firms with LOGVA=14 the derivatives are 1.3 for exporting and 0.5 for importing. For very large firms with LOGVA=23 the derivative falls to 0.5 for exporting and increases to 1.6 for importing.

Geographic concentration (GEOCON) has the expected positive coefficient, which is highly significant in each regression. Products whose production is highly concentrated in Brazil, and by inference are highly traded domestically, are also more apt to enter international trade. This controls for the fact that some firms are likely to be exporters or importers simply by virtue of the fact that they belong to industries that produce highly tradable products.

The coefficients of the two protection variables have the expected signs in the export equation. The coefficient of NOMPROT is negative and significant at the five per cent level in a one-tailed test whereas that of EFFPROT is positive and nearly significant at the ten per cent level in a one-tailed test. The effect of NOMPROT is stronger than that of EFFPROT, for a decrease in nominal protection represents an increase in export/domestic relative prices and causes producers to switch from domestic to export markets whereas an increase in effective protection, via a decrease in the price of raw materials and intermediate inputs, causes producers to increase their output for both domestic and export markets.

For import probabilities, the effect of protection, when measured by NOMPROT (or, for that matter, EFFPROT), is positive and highly significant. If a firm operates in a highly protected industry it is more likely to import manufactured goods than is an otherwise comparable

firm operating in an internationally competitive industry. There is no strong reason to predict such a finding, but it may reflect government policies that facilitate imports by firms in protected industries.

Finally, the coefficient of the dummy variable X is 1.5 in equation 2 indicating that the odds that an exporter is an importer are 4.5 times greater than those for a similar firm that does not export. Suppose for example, that a firm does not export and has a 50% probability of importing; if it were to have the same characteristics and export as well, the probability of importing would rise to 82 per cent. It is, of course, conceivable that the causation runs the other way as well, that is, that the existence of imports increases the probability of exporting, but the application of a test proposed by Lee [*1981*] supports the recursive structure of the model and lends no support at all to the hypothesis of simultaneity.[5]

Additional industry-specific variables never attained statistical significance in the logit regressions, so are not reported in Table 2. Following a suggestion of Auquier [*1980*], the Herfindahl index of concentration was added to the export equation on the assumption that small firms are induced to export from highly concentrated industries. The logarithm of the number of plants was added to each equation to test whether size might be more appropriately measured as plant size rather than firm size. And, following Blomström and Persson [*1983*], the proportion of domestic sales accounted for by foreign-owned firms was included in order to test for 'spill-over' effects of foreign investment on domestic firms. In no case were the coefficients of these variables significantly different from zero, regardless of whether the square of LOGVA was included in the equation along with LOGVA or not.

2. *Exports of Exporters*

OLS regression results for the third equation of the model are reported in Table 3. Four alternative specifications are reported; in each equation dummy variables capture the effect of omitted variables that vary by industry. Versions 3c and 3d contain interaction effects; in these two regressions the effect of size on exports is free to vary from industry to industry. With 171 industry dummies, it was neither possible nor necessary to include the three industry-specific variables (GEOCON, NOMPROT and EFFPROT) in the OLS regressions.

The coefficient of foreign ownership is positive as expected and highly significant. The parameter estimate of 0.5 implies that foreign-owned exporters register on average 65% more exports than otherwise comparable domestically owned exporters. This is very similar to estimates obtained with 1978 Brazilian data and reported in Willmore [*1985; 1986*].

TABLE 2

LOGIT ANALYSIS OF EXPORT/IMPORT PROBABILITIES

Regressor	$\log \frac{Pr(X=1)}{Pr(X=0)}$	$\log \frac{Pr(M=1\|X)}{Pr(M=0\|X)}$
	1	2
Intercept	-32.148[a/]	-7.955[a/]
FOR	1.322**	2.898**
	(0.408)	(0.779)
STATE	-0.760	-0.131
	(1.189)	(1.536)
RD	0.065	4.074
	(0.984)	(9.005)
ADV	28.171**	12.576**
	(3.712)	(3.894)
LOGWAGE	-0.094	0.590**
	(0.061)	(0.086)
LOGNVA/L	-0.068**	-0.032+
	(0.014)	(0.017)
LOGVA/Q	-0.695**	-0.446**
	(0.078)	(0.099)
LOGVA	2.529**	-1.210*
	(0.537)	(0.604)
$LOGVA^2$	-0.044**	0.061**
	(0.016)	(0.018)
GEOCON	1.531**	0.706**
	(0.198)	(0.239)
NOMPROT	-0.440+	0.570**
	(0.244)	(0.208)
EFFPROT	0.122	
	(0.101)	
X		1.514**
		(0.096)
McFadden's R^2	.33	.43

Note: The numbers in parentheses are asymptotic standard errors of the estimated coefficients. A plus (+) indicates significance at the 10% level of confidence, a single asterisk at the 5% level and a double asterisk (**) at the 1% level.

a/ The intercept varies by industry group. The statistics reported in this table are weighted average intercepts, the weights being the number of observations in each of the 21 industry groups.

TABLE 3
OLS ANALYSIS OF THE EXPORT PERFORMANCE OF EXPORTERS

Regressor	Equation			
	3a	3b	3c	3d
Intercept	-0.396[a/]	18.657[a/]	b/	b/
FOR	0.593**	0.508**	0.476**	0.513**
	(0.117)	(0.118	(0.124)	(0.150)
STATE	0.844	0.248	0.190	0.740
	(0.828)	(0.832)	(1.187)	(1.343)
RD	0.309	0.261	0.096	0.018
	(0.434)	(0.432)	(0.471)	(0.515)
ADV	11.392**	11.205**	13.363**	9.117+
	(3.091)	(3.078)	(3.290)	(5.419)
LOGWAGE	-0.295**	-0.296**	-0.313**	-0.358*
	(0.077)	(0.077)	(0.081)	(0.152)
LOGNWVA/L	-0.012	-0.001	0.003	
	(0.017)	(0.017)	(0.018)	
LOGKL				0.295**
				(0.082)
LOGVA/Q	-0.959**	-0.884**	-0.956**	-0.965**
	(0.105)	(0.105)	(0.116)	(0.201)
LOGVA	1.011**	-1.086**	b/	b/
	(0.030)	(0.372)		
$LOGVA^2$		0.057**	b/	b/
		(0.010)		
Adjusted R^2	.407	.412	.415	.365
Degrees of freedom	3585	3584	3293	1396

Notes: Dependent variable is LOGX|X=1. The numbers in parentheses are the standard errors of the estimated coefficients. A plus (+) indicates that a coefficient is significantly different from zero at the ten percent level of confidence in a two-tailed test. A single asterisk (*) indicates significance at the five percent level and a double asterisk (**) indicates significance at the 1% level.

a/ Intercept varies by four-digit industry. The statistic reported in this table is the weighted average intercept, the weights being the number of observations in each of 171 industries.

b/ Coefficient varies by four-digit industry. The estimated parameters are not reported here, but are available from the author upon request.

The coefficients of STATE ownership and RD are positive, but fail to achieve statistical significance in any of the export regressions. These two variables thus have no significant effect on the performance of a firm that exports.

Advertising intensity (ADV) has a positive and highly significant coefficient, replicating the results of Willmore [*1985*]. This finding is consistent with the hypothesis that firms in monopolistic competitition are price discriminators and that they have high export propensities because their long-run marginal costs of production are well below long-run average costs.

The coefficient of the labour skill variable (LOGWAGE) is negative as expected, highly significant, and not very sensitive to changes in the specification of the regression equation. On average, a ten percent higher wage is associated with a three per cent lower volume of exports.

Capital intensity has virtually no effect on LOGX when measured as LOGNWVA/L and a significantly positive effect when measured as LOGK/L. There is no evidence that capital intensity inhibits exports *once the firm enters export markets* and there is some evidence that capital intensity may be associated with higher export propensities. This finding lends only weak support to the conclusion of Willmore [*1985*].

The coefficient of vertical integration (LOGVA/Q) is negative as expected and highly significant. It is affected very little by changes in the specification of the regression equation. On average, an increase of one percent in the ratio of value-added to output is associated with a decrease of nearly one percent in exports.

The coefficient of LOGVA is not significantly different from unity in equation (3a), which implies the absence of any correlation between export/output ratios and total output. This finding supports the conclusion of my 1985 study and is consistent with the negative correlation found in that study between domestic sales and export/domestic sales ratios. With the addition of a quadratic term for LOGVA in equation 3b, the size elasticity exceeds unity for firms larger than the average exporter (LOGVA=18.3) and is less than unity for smaller firms. As a result, in equation (3b) export/output ratios are first a declining and then an increasing function of size. In equations (3c) and (3d) LOGVA and its square are allowed to vary by industry, with little effect on other coefficients in the regression.

3. Imports of Importers

Table 4 reports the OLS regression results for four specifications of the fourth and last equation of the model. Again the industry dummies replace industry-specific variables and again the coefficient of FOR is

positive as expected and highly significant. In contrast to the logit regressions, the coefficient of FOR in the import equation is only slightly larger than that in the export equation.

The coefficient of STATE in the LOGM regressions is positive, but loses statistical significance when coefficients of the size variables are allowed to vary by industry. The coefficient of RD is negative and retains a statistical significance of 10 per cent in a two-tailed test in all specifications of the equation; given the fact a firm imports some of its manufactured inputs, the existence of a programme of research and development thus appears to decrease its dependence on those imports. ADV also has a negative coefficient, which contrasts sharply with its positive coefficient in the other three equations, but it is statistically significant only in regression equation (4d).

Capital intensity has a negative effect on imports, reinforcing its negative effect on the probability of importing, but the coefficient is not statistically significant when capital intensity is measured by fixed assets per employee (LOGK/L).

The coefficient of vertical integration (LOGVA/Q) is negative as expected and highly significant. Firms with a higher ratio of value added to output produce a larger proportion of their inputs within the firm, relying less on foreign suppliers.

LOGVA has the expected positive effect on imports, but the coefficient is less than unity in equation (4a), implying that import/output ratios are a decreasing function of firm size. In equation (4b), the partial derivative of LOGVA is greater than unity for LOGVA greater than 20.2. Controlling for the effects of other variables on imports, only for very large firms is there any evidence that import/output ratios increase with the size of importers. This finding is similar to that found for export/output ratios of exporters.

Entering X and LOGX jointly in equation (4) produces a positive, statistically significant coefficient for LOGX along with a negative coefficient for X. This is evidence of a positive relationship between the quantity of imports and the quantity of exports, but the relationship is a weak one: for firms that export and import, an increase of one per cent in exports results in an increase of less than one-tenth of one per cent in imports. None the less, one should bear in mind that exporting has a strong positive effect on the probability of importing in the first instance. Moreover, the import data are restricted to imports of manufactures. It is quite possible that one might find a stronger relationship if imports were to include raw materials.[6]

In cross-section studies of this type, there is reason to expect the OLS regression results to be affected by heteroscedasticity. To allow for this

TABLE 4
OLS ANALYSIS OF THE IMPORTS OF IMPORTERS

Regressor	Equation			
	4a	4b	4c	4d
Intercept	-6.076[a/]	13.741[a/]	b/	b/
FOR	0.729** (0.089)	0.678** (0.088)	0.622** (0.091)	0.806** (0.109)
STATE	1.507* (0.593)	1.033+ (0.591)	0.441 (0.778)	0.760 (0.938)
RD	-0.512+ (0.302)	-0.544+ (0.299)	-0.600+ (0.311)	-0.568+ (0.323)
ADV	-3.624 (2.461)	-3.542 (2.438)	-3.390 (2.534)	-10.219** (3.686)
LOGWAGE	0.465** (0.069)	0.471** (0.068)	0.453** (0.072)	0.396** (0.120)
LOGNVA/L	0.043** (0.015)	0.061** (0.015)	0.069** (0.015)	
LOGKL				-0.048 (0.059)
LOGVA/Q	-1.110** (0.092)	-1.074** (0.091)	-1.075** (0.100)	-1.032** (0.146)
LOGVA	0.779** (0.030)	-1.419** (0.307)	b/	b/
$LOGVA^2$		0.060** (0.008)	b/	b/
X	-0.928** (0.259)	-0.534* (0.262)	-0.563* (0.269)	-0.279 (0.367)
LOGX	0.065** (0.017)	0.040* (0.017)	0.039* (0.017)	0.021 (0.023)
Adjusted R^2	0.482	0.491	0.518	0.485
Degrees of freedom	2648	2647	2167	1185

Note: Dependent variable is LOGM|M=1,X,LOGCX). The numbers in parentheses are the standard errors of the estimated coefficients. A plus (+) indicates that a coefficient is significantly different from zero at the ten percent level of confidence in a two-tailed test. A single asterisk (*) indicates significance at the five percent level and a double asterisk (**) at the 1% level.

a/ Intercept varies by four-digit industry. The statistic reported in this table is the weighted average intercept, the weights being the number of observations in each of the 160 industries.

b/Coefficient varies by four-digit industry. The estimated parameters are available from the author upon request.

possibility I estimated the standard errors of the parameters of equations (3b) and (4b) using a method suggested by White [*1980*]. I found heteroscedasticity to have little effect on the calculated standard errors of the coefficients of the firm-specific variables. Differences between the OLS and White estimates of the standard errors of the coefficients of the industry dummies were, however, quite large in a number of cases. The only important alterations to the OLS findings for firm-specific variables was in equation (4b), where White's method increased the statistical significance of STATE and RD from ten per cent to the five per cent level in a two-tailed test.

4. Results for the Full Model

For exports, a full solution of the model requires multiplication of the probability of exporting calculated from the first equation times the exports a firm would record if it were in fact an exporter:

$$\text{EXPORTS} = \Pr(X=1) \quad \exp(\text{LOGX}|X=1) \tag{5.0}$$

For imports, the solution is similar except that the continuous variable Pr(X=1) substitutes the dichotomous variable X and the expected value of LOGX calculated from the third equation substitutes observed LOGX. This permits the calculation of import probabilities and import values solely on the basis of exogenous variables. Expected imports are then the probability of importing times the imports a firm would register if it were in fact an importer:

$$\text{IMPORTS} = \Pr(M=1) * \exp(\text{LOGM}|M=1) \tag{6.0}$$

To express EXPORTS and IMPORTS in terms of variables exogenous to the model results in very complex equations. Simulation of the effects of changes in exogenous variables on EXPORTS and IMPORTS is a simpler way of illustrating the working of the model. Consider the 652 foreign-owned firms in our sample. The first two columns of Table 5 show that the model tends to overestimate the number of exporters and importers and to underestimate both exports and imports, but the overall fit is rather good. Suppose that a law is passed requiring the sale of all foreign-owned firms to Brazilian investors. Under the heroic assumption that such a transfer of ownership would have no effect on other exogenous variables, the model predicts that the number of exporters will fall by 22 per cent and the number of importers by 27per cent. Exports will fall 43 per cent ($941 million) and imports 50 per cent ($975 million) with a consequent rise in the export/import ratio from 1.14 to 1.33. This

TABLE 5
SIMULATION OF THE TRADE PERFORMANCE OF 652 FOREIGN-OWNED FIRMS TRANSFERRED TO PRIVATE DOMESTIC OWNERS

	Foreign Ownership		Private Domestic Ownership		
	Actual	Predicted	Base Case[a/]	Reduced Size[b/]	Reduced Wages[c/]
Number of Firms	652	652	652	1204	1204
Exporters (%)	78.2	84.5	65.6	54.6	55.8
Importers (%)	84.8	95.9	69.8	56.6	50.7
Exports (million dollars)	2332	2210	1269	887	1094
Imports (million dollars)	2018	1931	956	805	568
Exports/Imports	1.16	1.14	1.33	1.10	1.93

Source: Regression equations 1, 2, 3b and 4b.

Notes: Cruzeiro values were converted at the average exchange rate in effect during 1980 (cr$52.71 per U.S. dollar).

a/ Foreign ownership dummy (FOR) is changed from 1 to 0. All other variables retain their observed values.

b/ In addition to change from FOR=1, the size of each firm (value-added) is reduced by one-half and the number of firms is doubled.

c/ Same as reduced size, except that the average wage of each firm is reduced by one-half.

simulation is reported in the third column of Table 5 and is referred to as the base case.

The sale of 652 transnational affiliates to local enterpreneurs is likely to affect other variables exogenous to the system. Foreign-owned firms, for example, are typically much larger than their locally-owned competitors. Suppose that each of the 652 firms is divided, with each half sold to a different investor. The fourth column of Table 5 shows that the number of firms engaged in foreign trade will increase, but the percentage of firms engaged in foreign trade will fall. Exports fall 30 per cent and imports 16 per cent compared to the base case, lowering the export/import ratio from 1.33 to 1.10.

Foreign-owned firms in Brazil are known [*Willmore, 1986*] to pay 40 per cent higher wages per employee, on average, than locally-owned

firms of similar size operating in the same industry. Moreover, there is a positive correlation between firm size and wages (the simple correlation between LOGVA and LOGWAGE for the 17,053 firms of this sample is 0.48). If the smaller, locally-owned firms pay wages that are only half those paid by the foreign owners, exports increase 23 per cent but are still below the level of the base case and imports fall a further 29 per cent to $568 million. As a result, the export/import ratio rises to 1.93 (see the last column of Table 5).

V. SUMMARY AND CONCLUSIONS

This paper represents an attempt to model, for the first time, the determinants of exports and imports of manufactures at the level of the individual firm. Its main conclusion can be stated quite succinctly: foreign ownership of Brazilian industry has a very strong, positive, independent effect on both export performance and import propensities, but foreign ownership in itself explains little of the relatively low export/import ratios registered by affiliates of transnationals. If the foreign-owned firms of the sample were transferred to private Brazilian ownership with no change in other exogenous variables, their exports would fall by 43 per cent and their imports by 50 per cent.

Size of firm, like foreign ownership, has a positive effect on exports and imports, but the effect is stronger for exports than for imports. Foreign-owned firms tend to be larger than their domestic rivals, and this contributes to the high observed export and import propensities of transnationals in Brazil.

Skill intensity, as measured by the average wage paid to employees of a firm, has a negative effect on exports and a positive effect on imports, hence a strong negative effect on export/import ratios. Transnationals pay higher wages, on average, than other firms, so this explains in part their relatively low export/import ratios.

Research and development expenditures by the firm have no significant effect on its exports, but they do have a modest, negative effect on its imports. This is evidence that technological effort results in increased use of domestic inputs, reducing a firm's dependence on imports in the production process.

Advertising intensity has a positive effect on the probability of exporting and on the volume of exports. Transnationals are shown in Willmore [*1986*] to advertise more than otherwise comparable locally-owned firms, so this is another reason to expect exceptional export performance on the part of transnationals. The effect of advertising on import propensities is

weak and ambiguous: positive for the probability of importing and negative for imports of importers.

What do these findings have to do with net exports of manufactures for the economy as a whole? Possibly very little, for the model ignores import substitution and, for virtually all firms in our sample, the domestic market is much more important than foreign markets. It is quite likely that, because of import substitution, the indirect effects of foreign ownership and other variables on the trade balances swamp the direct effects modelled in this article.

NOTES

1. For details, see Willmore [*1987*].
2. Numerous studies have examined the export and import propensities of foreign *vis-à-vis* domestic firms. For a recent survey, see Jenkins [*1990: 217–22*].
3. To my knowledge, this is the first time that nominal protection and effective protection have been entered simultaneously in a regression explaining export performance.
4. The antilog of 1.322 is 3.75 and that of 2.898 is 18.14.
5. The coefficient of Lee's synthetic variable G, when entered in equation (1) along with the variable M, is 1.35 with a standard error of 0.46. Simultaneity requires a coefficient of zero for G, whereas the fully recursive logit model requires a coefficient of unity.
6. But Baumann [*1985: 134–6*] reports a very weak relationship between export performance and imports of all inputs.

REFERENCES

Auquier, A.A., 1980, 'Sizes of Firms, Exporting Behaviour and the Structure of French Industry', *Journal of Industrial Economics*, Vol.29, No.2, pp.203–18.

Baumann, R., 1985, *Exportaçoes e Crescimento Industrial no Brasil*, Rio de Janeiro: Instituto de Planejamento Econômico e Social.

Blomström, M. and H. Persson, 1983, 'Foreign Investment and "Spillover" Efficiency in an Underdeveloped Country: Evidence for the Mexican Manufacturing Industry', *World Development*, Vol.11, No.6, pp.493–501.

Braga, H.C. and L.N. Willmore, 1991, 'Technological Imports and Technological Effort: An Analysis of their Determinants in Brazilian Firms', *Journal of Industrial Economics*, Vol.39, No.3, pp.421–3.

Drèze, J., 1960, 'Quelques Reflexions Sereines sur l'Adaptation de l'Industrie Belge au Marche Comun', *Comptes Rendus des Travaux de la Societé Royale d'Economie Politique de Belgique*, No.275, Dec.

Jenkins, R., 1990, 'Comparing Foreign Subsidiaries and Local Firms in LDCs: Theoretical Issues and Empirical Evidence', *Journal of Development Studies*, Vol.26,No.2, pp.205–28.

Lee, L.F., 1981, 'Fully Recursive Probability Models for the Analysis of Qualitiative Data', *Journal of Econometrics*, Vol.16, pp.51–69.

Pindyck, R.S. and D.L. Rubinfeld, 1981, *Econometric Models and Economic Forecasts*, New York: McGraw-Hill.

White, H., 1980, 'A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity', *Econometrica*, Vol.48, May, pp.817–38.

Willmore, L.N., 1985, *Market Structure, Firm Size and Brazilian Exports*, Brasilia: United Nations Estudios e Informes de la CEPAL 44.
Willmore, L.N., 1986, 'The Comparative Performance of Foreign and Domestic Firms in Brazil', *World Development*, Vol.14, No.4, pp.489–502.
Willmore, L.N., 1987, 'Controle Estrangeiro e Concentraçao na Indústria Brasileira', *Pesquisa e Planejamento Econômico*, Vol.17, No.1, pp.161–89.