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FOREIGN CONTROL AND CONCENTRATION IN BRAZILIAN INDUSTRY

Larry Willmore *

Data for the year 1980 reveal seller concentration to be high for domestic sales and exports, but large sellers in the domestic market often fail to rank among the largest exporters. Foreign-owned firms and joint ventures account for more than a quarter of sales in the domestic market and more than a third of the exports. High levels of concentration are associated with few firms and high foreign control. Foreign-owned firms tend to rank among the leaders of each industry, but this alone does not account for the positive correlation between foreign control and seller concentration.

Introduction

A researcher interested in industrial concentration is best advised to base his measures on data for firms rather than establishments, otherwise he will underestimate concentration in industries with multi-plant firms. The Brazilian Institute of Geography and Statistics (IBGE) collects data for individual establishments and does not normally group them by firm. Since IBGE is the main supplier of industrial statistics in Brazil, nearly all measures of industrial concentration, beginning with Fajnzylber's (1971) pioneering study, have been based on data for establishments rather than firms.

Two recent studies represent a sharp break from this tradition by calculating concentration ratios for firms as well as establishments. Moreover, both studies show concern -- for the first time in Brazil -- for the heterogeneity of the output of individual firms. Sidsamer and Barros

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(1982) analysed the 1974 industrial survey which, unlike other surveys and censuses of IBGE, contains information for 69,583 manufacturing plants grouped according to ownership by 60,514 firms. The entire output of each plant was allocated to the industry that accounts for the largest proportion of its sales, so the output of multi-plant firms could be allocated to more than one industry. Holanda (1983) also analysed 1974 data, but his source was the industrial product tax (IPI) returns covering 89,235 manufacturing firms that operated a total of 97,800 plants. Holanda's study contains detailed information on the diversifation of firms and plants by product line, so the output of all firms -- even single-plant firms -- could be allocated to more than one industry.

The data assembled for the present study refer to firms rather than establishments, but they include no information at all on the heterogeneity of the output of individual firms, much less that of individual plants. In compensation, there is information on exports and foreign ownership. This allows us to measure seller concentration in domestic and export markets and to examine the relationship between foreign control and industrial concentration.

I The Data

The data base used in this study contains information for 49,769 firms which operated 55,730 plants in Brazil's manufacturing sector in 1980. Included are all exporters, all state enterprises and all firms with foreign equity participation. Although the firms in our sample operate only twenty-five percent of the total number of manufacturing establishments included in the 1980 industrial census, they account for well over 95% of the total output of the sector.

These data were assembled from income tax returns filed by companies in 1981. 1/ The returns refer to fiscal 1980, which varies by firm, but

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1/ Information on the number of plants operated by each firm was obtained by crossing the income tax returns with industrial product tax (IPI) data.

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in most cases coincides with the calendar year. To improve inter-firm comparability, cruzeiro figures for firms with a fiscal year ending before December 1980 were adjusted upwards according to variations in the wholesale price index for industrial goods. The sales data exclude indirect taxes and revenue from the sale of real estate, but include export subsidies. These data, unlike those of industrial surveys and censuses, distinguish between exports and sales to the domestic market and contain information on state and foreign ownership of companies. Individual firms are not identified by name, and care has been taken not to reveal any statistics which might be used to infer results for a particular firm.

A major shortcoming of income tax data is that they fail to classify as 'foreign' those firms which are controlled from abroad through holding companies or through other firms established in Brazil. The leading producer of cigarettes, for example, appears from the tax returns to be wholly owned by residents of Brazil because BAT Industries Ltd. of the United Kingdom controls the firm through its Rio de Janeiro holding company. Similarly General Electric do Nordeste S.A. is misclassified as a local firm because its shares are held by General Electric do Brasil S.A. which in turn is owned by General Electric Corporation of the USA. Inadvertant underestimation of the extent of foreign ownership has characterized nearly all studies based on tax returns, viz Braga 1981, Mascolo and Braga 1984, and Willmore 1985a. At least two studies, however, have corrected this flaw in corporate income tax data (Calabi et al. 1981 and Willmore 1985b). In the present study we improved the estimates of foreign participation by crossing the income tax data with published balance sheets of large industrial firms. Nonetheless it is likely that a number of small foreign-owned companies remain misclassified as local firms. The estimates of foreign control reported here are thus biased downwards by a small, but unknown, amount.

x2 =

As reported in table 1, the vast majority of the firms in the sample are privately-owned by residents of Brazil. These local firms account for more than half of the sales in both the domestic and export markets. In only 1,089 firms do nonresidents hold more than ten percent of the equity, but these foreign-owned firms are responsible for 27.5 percent of domestic sales and 38.3 percent of exports. If we restrict our definition of 'foreign' firms to those in which nonresidents hold more than half the equity, the number of foreign firms falls to 794 and their participation in the sample falls to 22.5% of domestic sales, 31.2% of exports and 23.3% of total sales. The participation of private 'Brazilian' firms increases accordingly. Finally, 43 state enterprises, of which ten are joint ventures with minority foreign participation, account for thirteen percent of sales in the domestic market and 7.5% of exports.

Table 2 reports the participation of the three types of firms in total sales of 23 manufacturing subsectors. Privately-owned Brazilian firms account for more than half the sales in sixteen subsectors and for more than a quarter of the sales in the remaining seven subsectors. The participation of foreign-owned firms varies from a low of three percent in

Table 1. Participation of Private Brazilian, Foreign-Owned and State-Owned Firms in Domestic Sales, Exports and Total Sales, 1980.

	NUMBER OF FIRMS	DOMESTIC SALES (%)	EXPORTS (%)	TOTAL SALES (%)
Private Brazilian	48 615	59.5	54.2	59.0
Foreign	1 089	27.5	38.3	28.5
State	65	13.0	7.5	12.5
TOTAL	49 769	100.0	100.0	100.0

Source: 1980 data base.

Note: A foreign firm is defined as one in which nonresidents own more than ten percent of the equity and state participation is nonexistent or minimal. State enterprises include 'mixed' firms of public and private capital provided that state ownership is dominant. The remaining enterprises are regarded as 'private Brazilian' for the purpose of this study.

Table 2. Participation of Private Brazilian, Foreign-Owned and State-Owned Firms in Total Sales, by Subsector, 1980. (percentages)

Subsector	Private Brazilian	Foreign	State
Non-metallic minerals	72	28	a/
Basic iron and steel	37	23	40
Basic non-ferrous metals	56	44	0
Metal products	75	23	2
Machinery	59	41	0
Electrical equipment	56	44	0
Transport equipment	29	68	3
Wood	95	5	0
Furniture	97	3	0
Pulp and paper	75	21	5
Rubber	37	63	0
Leather	85	15	0
Chemicals	27	21	52
Pharmaceutical	28	71	1
Perfumes and soaps	47	53	0
Plastics	83	17	0
Textiles	78	22	a/
Clothing and footwear	96	4	0
Food products	81	18	1
Beverages	85	15	a/
Tobacco	27	73	0
Printing and publishing	91	3	6
Other manufactures	70	29	1
TOTAL MANUFACTURING	59	28.5	12.5

Source: 1980 data base.

a/ Less than 0.5.

furniture to a high of 73 percent in tobacco. In five subsectors — transport equipment, rubber, pharmaceuticals, perfumes and soaps, and tobacco — foreign firms account for a majority of total industry sales. State enterprises are present in twelve of the twenty-three subsectors, but they are heavily concentrated in steel, petroleum refining and petro-chemicals.

The finding that 1,089 foreign-owned firms accounted for 28.5% of Brazil's manufacturing production in 1980 is at odds with an earlier estimate (ECLAC 1983, p. 66) estimate that 647 transnational subsidiaries produced 32% of the total output of the manufacturing sector in 1977. This might indicate that foreign participation in Brazilian manufacturing fell drastically between 1977 and 1980. It more likely reflects an underestimate of the nominal value of total manufacturing output in 1977.

Authors of the 1983 ECLAC report had access to information on the sales of foreign-owned firms, but they applied price and output indices to the data of the 1974 industrial survey in order to estimate total industry sales in 1977. Price indices are notoriously unreliable for Brazilian manufactures.

Other researchers, working with samples of the largest firms, have reported much higher levels of foreign participation in the manufacturing sector. Foreign firms are larger on average than local firms, so the omission of small and medium-sized firms imparts an upward bias to estimates of foreign control. Von Doellinger and Cavalcanti (1975), for example, found foreign-owned firms to account for 55% of the sales in their sample of 318 large manufacturing enterprises. Calabi et al. (1981, tables 2.6 and 2.9) included 3,167 manufacturing firms in their data base, with the result that majority-owned foreign firms accounted for 38% of industry output.

In sum, transnational enterprises do not control a particularly large portion of Brazil's total manufacturing output. At issue, however, is their concentration in the 'commanding heights' of the economy and their dominance of individual industries such as cigarettes, pharmaceuticals, automobiles and rubber tyres.

II Aggregate Concentration

The findings reported in the second line of table 3 show aggregate concentration to be quite high in Brazilian manufacturing, with 100 companies accounting for nearly a third of domestic shipments, and 500 firms accounting for more than half. This degree of concentration is similar to that found by Holanda (1983, pp. 91-92) and somewhat higher than that reported in Sidsamer and Barros (1982, p.51). To place these figures in perspective, it should be noted that aggregate concentration in Brazil's manufacturing sector is well below that of West Germany, Canada and the United Kingdom and somewhat below that of the United States at the

Table 3. Characteristics of the Largest Industrial Firms Ranked by Domestic Sales, 1980

	C100	C200	C500	C1000
Average plants per firm	3.5	3.5	2.9	2.5
Domestic sales (% of total)	30.8	38.4	50.7	62.5
Exports (% of total)	32.2	39.6	53.7	65.1
Export/sales ratio (%)	9.7	9.6	9.8	9.9
Number of exporters	90	166	393	708
Private Brazilian firms:				
Number	30	85	271	649
Share of domestic sales (%)	15.1	22.9	32.3	39.4
Foreign-owned firms: b/				
Number	61	102	209	323
Share of domestic sales (%)	45.6	44.9	42.6	39.4
State-owned firms:				
Number	9	13	20	28
Share of domestic sales (%)	39.3	32.2	25.1	21.2

Source: 1980 data base.

a/ C100 refers to the largest 100 firms, C200 the largest 200, C500 the largest 500, and C1000 the largest thousand.

b/ A foreign firm is defined as one in which nonresidents own more than ten percent of the equity

present time; it is similar to levels registered in the United Kingdom and the United States thirty years ago. (See Scherer 1980, p. 45-51, Curry and George 1983, pp. 227-229, and the references cited therein.)

As is well-known, exports are even more concentrated than domestic sales, with 200 firms accounting for two-thirds of total exports of manufactures in 1980. (See table 4.) What is not generally appreciated, however, is that the largest exporters and the largest firms in the domestic market are not always the same companies. In fact, many of the largest manufacturers do not export any of their output at all, and the overall export/sales ratio for leading firms in the domestic market is less than ten percent, not much higher than the 9.1% registered by the entire sample of nearly fifty thousand firms. This point is elaborated in table 5, which reports the number of firms common to lists of leading

Table 4. Characteristics of the Largest Industrial Firms Ranked by Exports, 1980

	C100	C200	C500	C1000
Average plants per firm	2.9	2.4	2.3	2.1
Exports (% of total)	54.1	67.1	83.2	92.7
Domestic sales (% of total)	22.5	26.4	35.6	43.7
Export/sales ratio (%)	19.9	20.8	19.4	17.9
Private Brazilian firms:				
Number	55	124	335	720
Share of exports (%)	37.8	43.8	49.0	51.8
Foreign-owned firms: b/				
Number	37	67	152	265
Share of exports (%)	49.2	45.5	42.0	40.1
State-owned firms:				
Number	8	9	13	15
Share of exports (%)	13.0	10.7	9.0	8.1

Source: 1980 data base.

a/ C100 refers to the largest 100 exporters, C200 the largest 200, C500 the largest 500 and C1000 the largest thousand.

b/ A foreign firm is defined as one in which nonresidents own more than ten percent of the equity

firms when the firms are ranked alternatively by exports and by domestic sales. Looking at the diagonal of this table, for example, 36 firms rank among the top 100 exporters and the top 100 in domestic sales, and 66 firms rank among the top 200 of both lists. Reading across the second row, it is evident that 51 of the largest 200 firms in domestic sales rank among the leading 100 exporters, while 129 of these same 200 firms rank among the thousand largest exporters.

With respect to the ownership of the largest firms ranked by domestic shipments (table 3), transnational corporations own 61 of the leading 100 firms, and their total output is three times as large as that of the thirty local firms and somehat larger than that of the nine giant state-owned enterprises. As the list of largest firms increases, the share of private Brazilian firms increases and the shares of foreign-owned and state enterprises decreases. For the largest thousand firms, foreign and

Table 5. Number of Firms Which Rank among the Leading Sellers in both Domestic and Export Markets, 1980.

DOMESTIC SALES	EXPORTS			
	C100	C200	C500	C1000
C100	36	44	63	76
C200	51	66	102	129
C500	75	113	203	279
C1000	85	146	285	437

Source: 1980 data base.

Note: C100 refers to the largest 100 firms, C200 the largest 200, C500 the largest 500, and C1000 the largest thousand.

local firms have equal shares of domestic shipments (39.4%) and public enterprises rank third with 21.2% of shipments. This illustrates nicely the point that restricting samples to large firms biases upwards the participation of both foreign-owned and state enterprises in total industry output. Among the largest exporters, the participation of privately owned Brazilian firms rivals that of transnationals while state enterprises play a very modest role. (See table 4.)

A serious defect of the present study, and all previous studies of concentration in Brazil, is its neglect of economic groups. Several firms are often under the ownership and control of a single economic group, biasing downwards measures of concentration based on a legalistic definition of the firm. Wealthy Brazilian families tend, to a much greater extent than transnational or state enterprises, to own a large number of firms, so the data also understate the importance of local entrepreneurs in the 'commanding heights' of the economy. Typically the firms of an economic group operate in distinct industries, so calculations of seller concentration in individual industries are not biased. Cement and beverages, two industries which operate in regional markets due to high transportation costs, are exceptions to this generalization. In 1984 the Votorantim group owned fifteen of the fifty cement companies listed in

the 'Quem e Quem' survey and two groups -- Brahma and Antarctica -- owned seven of the eight largest beer companies.

Limitations of time prevented us from correcting the data base for the existence of economic groups, but an indication of the extent of the resulting bias is evident from the 'Quem e Quem' survey results for the largest 7,535 non-financial firms in 1980 and the largest 8,099 firms in 1984. The leading 100 firms accounted for forty percent of the total operating revenue of the firms surveyed in 1980 and 44 percent in 1984. Grouping together all firms with common ownership, this index of aggregate concentration increases by ten percentage points: to fifty percent in 1980 and 54 percent in 1984. Equally striking is the effect that consolidation of firms by economic group makes on the ownership distribution of the leading firms. For 1980, 35 local firms rank among the leading 100 and they account for twenty percent of the operating revenue; when firms under common ownership are grouped together the number of local firms ranking in the top 100 increases to 53 and their participation in operating revenue to 30.7 percent. (See table 6.) Results for 1984 are similar. Disregard of economic groups causes us to understate the importance of domestic private firms and overstate that of state and, to a lesser extent, transnational enterprises.

Table 6. Distribution of the 100 Largest Non-Financial Enterprises by Ownership, 1980 and 1984.

	1980		1984	
	Firms	Groups	Firms	Groups
Private Brazilian				
Number	35	53	39	57
Share of Revenue (%)	19.9	30.7	22.7	33.6
Foreign				
Number	34	37	28	31
Share of Revenue (%)	33.6	31.0	27.4	24.9
State				
Number	31	10	33	12
Share of Revenue (%)	46.5	38.3	49.9	41.5

Source: 'Quem e quem na economia brasileira', Visao, August 1981 and August 1985.

Note: A foreign firm is defined as one controlled by non-residents.

The 1980 and 1984 'Quem e Quem' surveys also show that three years of economic recession had a greater impact on foreign firms than on locally owned firms or public enterprises. Both the number of foreign-owned firms and their participation in the leading 100 firms fell between 1980 and 1984, while the number of firms and the participation increased for both private Brazilian and state-owned firms. It is possible that this is a continuation of a long-term trend rather than a cyclical movement, for Penalver et al. (1983) report that the foreign share of the book value of the net assets of manufacturing firms included in the annual 'Quem e Quem' survey decreased from 34.4% in 1971 to 22.5% in 1979. Simultaneously, the share of state enterprises increased from 18.5% to 22.5% and that of private Brazilian firms from 47.1% to 55.0%. It is, however, difficult to place much confidence in these figures, for at the same time 'Quem e Quem' coverage of manufacturing firms nearly doubled (from 1,898 in 1971 to 3,602 in 1979). Extending the survey coverage to a greater number of medium-sized firms automatically raises the apparent participation of private Brazilian firms relative to that of the transnationals.

III Concentration in Individual Industries

Brazil's tax authority (Secretaria da Receita Federal or SRF) has divided the manufacturing sector into 195 industries, each with a four-digit code. This classification system is more aggregate than the four-digit level of the Institute of Geography and Statistics (IBGE), but the two systems are identical at the two-digit level. Glass, for example, is a single industry in the SRF system, while IBGE identifies seven distinct 'glass' industries, ranging from plate glass to crystal. Like virtually all industrial classification systems, that of the SRF tends to be supply-oriented, overlooking possibilities for substitution on the demand side of the market. Wood furniture, metal furniture and plastic furniture, for example, are regarded as separate industries even though they are

substitutes in many uses. Nevertheless, there are some interesting exceptions to this general pattern. Both the luggage and footwear industries include products made of synthetic materials and cloth as well as those made of leather. A few of the industries are too finely defined for our purposes, so we have combined four different meat products industries into a single one and added commercial printing to 'other printing services', leaving a total of 191 industries.

Two measures of concentration have been calculated for domestic sales, exports and total sales for each of the 191 industries. The results are reported in detail in appendix tables available from the author. The four-firm concentration ratio (CR4) is simply the sales of the largest four firms in each industry as a percentage of sales by all firms classified to the industry. This type of ratio is widely used in industrial economics, and has been given theoretical underpinnings by Saving (1970), who assumes that the 'n' largest firms of an industry form a collusive core and the remaining firms operate as a competitive fringe. The Herfindahl (H) index is somewhat less popular, because its data requirements are more demanding. It is calculated as the sum of the squares of the shares of each individual firm in an industry. The H index takes a maximum value of unity in a one-firm industry and a maximum approaching unity and a minimum of 1/n in an industry with 'n' firms. Stigler (1964) derives the H index from a model of a cartel while Cowling and Waterson (1976) derive the same index from a model of Cournot oligopoly.

Summary statistics describing the distribution of the various measures of concentration are reported in table 7. In an attempt to restrict the analysis to meaningful industries, five miscellaneous 'industries' (1199, 1299, 2099, 2699 and 3099), five covering repair rather than manufacture (1280, 1390, 1413, 1424, 1472), six with highly regional rather than national markets (1010, 1011, 1020, 1030, 1050 and 2696) and one with low coverage (2013) have been deleted. The four-firm

Table 7. Summary Statistics for Concentration Indices, 1980. (174 Industries)

		mean	standard deviation	median	minimum	maximum
Domestic Sales	CR4	50.9	25.6	48.4	7.3	100.0
	H	.1486	.1710	.0909	.0038	.9467
Exports	CR4	83.3	19.9	92.8	17.4	100.0
	H	.4299	.3029	.3629	.0200	1.0000
Total Sales	CR4	51.6	25.4	49.0	7.7	100.0
	H	.1520	.1754	.0908	.0040	.9480

Source: 1980 data base.

Note: CR4 is the four-firm concentration ratio and H the Herfindahl index of concentration. Four industries registered no exports, so the statistics for exports refer to 170 industries.

concentration ratios (CR4) and the Herfindahl indices (H) are highly correlated for these 174 industries, the simple (Pearson) correlation being 0.840 for domestic sales, 0.758 for exports and 0.832 for total sales. The Spearman coefficients of rank correlation are even higher: 0.989, 0.914 and 0.988.

By any measure, it is obvious that exports are much more concentrated than domestic sales. It is noteworthy, however, that there is very little difference between domestic sales and total sales in average levels of concentration. In part, this reflects the low ratio of exports to total sales, but it also reflects the fact that the largest exporters in each industry are not necessarily the largest sellers in the domestic market. Concentration is higher for exports than for domestic sales in nearly all industries, yet for a substantial number of the 174 industries — 49 in the case of CR4 and 63 in the case of H — indices of concentration for total sales are actually lower than those for domestic sales. These findings confirm those reported in an earlier study based on Brazilian data for the year 1978 (Willmore 1985a, appendix A).

An unfortunate limitation of the present study is the absence of information on the extent of activities of firms outside their main

industry, i.e. the extent of product diversity of firms in our sample. Firms in Brazil, even relatively small firms which operate a single plant, tend to be quite diversified. Holanda (1983, pp. 105-113), in his analysis of data for 89,235 manufacturing firms classified into 324 four-digit industries, discovered that 23.1% of the net manufacturing shipments in 1974 were produced by firms operating outside the industry to which they were classified. Product diversity was greater for large firms, for the largest 163 firms in Holanda's data base received 29.1% of their net revenue from products outside the industry to which they were classified; this proportion was 22.4% for the next 1,351 firms and 17.8% for the smallest 87,271 firms. At the two-digit level, 10.8% of net shipments came from firms diversified into other subsectors; this proportion was 12.5% for large firms, 10.9% for medium-sized firms and 9.1% for small firms. Since the four-digit SRF classification lies between these two levels of aggregation, the incidence of diversity in our study should lie somewhere between 10.8% and 29.1% of total sales.

In calculating indices of seller concentration, it was not possible to measure or to adjust for product diversity in any way. A firm is assigned to an industry according to its primary activity, and all its sales are included in that industry. If a diversified firm classified to one industry is a dominant seller in that industry and others as well, seller concentration in the principal market will be overstated and that in secondary markets will be understated. If the firm is a minor seller in all markets, concentration will be understated in the principal market and overstated in other markets. Detailed data reported by Holanda (pp. 109-110) suggest these and other possibilities are common in Brazil, so it is impossible to know whether our measures of concentration are biased upwards or downwards on average as a result of our disregard of product diversity. The same observation is, of course, equally true for alternative estimates of seller concentration in Brazil, with the sole exception of those of Holanda.

IV The Components of Concentration

Caves et al. (1980, pp. 42-43) have noted that the four-firm concentration ratio can be decomposed into the relative size of the largest firms' plants, the relative number of plants operated by the largest firms, and the largest firms' proportion of the total number of firms in an industry. This is a useful identity because the elements of concentration may differ from industry to industry. One industry, for example, might show a high degree of concentration because the leading firms operate very large plants compared to their smaller counterparts, whereas another may show high concentration because its leading firms operate a large number of plants, and still another may show high concentration even if plant size and multiplant operations differ little between firms, simply because the industry contains a small number of firms. Algebraically, the relationship is

$$\frac{S4}{S} \equiv \frac{S4/NP4}{S/NP} \cdot \frac{NP4/4}{NP/N} \cdot \frac{4}{N} ,$$

where S represents sales, NP the number of plants and N the number of firms. The number 4 following a variable indicates that it refers to the largest four firms in an industry; otherwise the variable refers to the entire industry.

Since we are comparing the leading four firms with all firms in each industry, the decomposition is not very meaningful for industries with few firms. Removing two industries which have fewer than seven firms leaves us with 172 industries in our data base. The correlation matrix for the four-firm concentration ratio (total sales) and each of its three components is as follows:

	CR4 Ratio	relative plant size	relative no. of plants	no. of firms
CR4 ratio	1.000	-0.325	-0.184	-0.523
relative plant size		1.000	-0.174	0.560
relative no. of plants			1.000	0.134
number of firms				1.000

All coefficients are significantly different from zero at the ten percent level of confidence. These results are very similar to those reported by

Caves et al. for Canada. There is a strong inverse relationship between concentration and the number of firms in an industry, which confirms the finding of Bonelli (1980, pp. 865-866) for Brazil. There is also a significantly negative correlation between concentration and each of the other two components of the concentration ratio. This is to be expected since concentrated industries have fewer firms, hence fewer small firms, with the result that the leading four firms are closer in terms of size and multi-plant operations to the remaining N-4 firms. (Note the positive correlation between the number of firms, on the one hand, and the relative size and number of plants, on the other hand.)

Most surprisingly, holding the number of firms constant, the partial coefficient of correlation between concentration and relative plant size, and between concentration and the relative number of plants, are both negative (-0.045 and -0.135, respectively). These results, like the similar coefficients of partial correlation found by Caves et al., are implausible and appear to result from a failure to properly transform the variables before calculating correlation coefficients. The identity is multiplicative, hence additive in logarithms, so a logarithmic transformation of all variables is appropriate. Such a transformation does improve the coefficients of simple correlation, as can be seen in the following matrix:

	CR4 Ratio	relative plant size	relative no. of plants	no. of firms
CR4 ratio	1.000	-0.525	-0.215	-0.839
relative plant size		1.000	-0.168	0.781
relative no. of plants			1.000	0.387
number of firms				1.000

All coefficients are significantly different from zero at the five percent level. The correlation between concentration and the number of firms is particularly high; in fact, the logarithm of the number of firms would serve quite tolerably as a proxy for the logarithm of the concentration ratio. More importantly, when the number of firms is held constant, the partial correlation between CR4 and relative plant size is positive

(0.383), as is that between CR4 and the relative number of plants (0.219).

In sum, the number of firms operating in an industry is the most important component of seller concentration in Brazil: large numbers of firms imply low levels of concentration. Leading firms of concentrated industries tend to operate with plant sizes and numbers of plants that are similar to those of their smaller counterparts. Nonetheless, holding constant the number of firms that comprise an industry, an increase in either the size or the number of plants operated by leading firms relative to the industry as a whole is associated with higher levels of seller concentration.

V Concentration and Foreign Control

Table 8 reports, for 174 industries, the average levels of two indicators of foreign control: the foreign share of industry shipments (FS) and the foreign share of the shipments of the leading four firms in each industry (F4). Foreign-owned firms are defined quite broadly to include joint ventures of local and foreign capital provided that the latter holds ten percent or more of the total equity. On average, foreign-owned firms account for 22.7% of domestic shipments and 28.4% of exports in the 174 industries. Their control of shipments of the leading four firms (F4) is somewhat higher: 31 percent in the case of domestic sales and thirty percent in the case of exports. This reflects the fact that foreign-owned firms are larger, on average, than other firms in each industry. Details by industry are reported in an appendix table.

The confidential nature of these data prevents the listing by industry of the foreign share of the leading four firms (F4) because the market share of an individual firm could inadvertantly be disclosed. Nonetheless, it can be reported that in 42 of the 174 industries there is no apparent foreign investment at all; in an additional 25 industries none of the foreign-owned firms rank among the leading four firms.

Table 8. Summary Statistics for Indicators of Foreign Control, 1980. (174 industries)

		mean	standard deviation	median
Domestic Sales	FS	22.7	25.1	14.3
	F4	31.2	33.2	21.1
Exports a/	FS	28.4	33.0	13.0
	F4	30.3	35.3	12.2
Total Sales	FS	23.0	25.1	14.0
	F4	31.5	33.0	21.9

Source: 1980 data base.

Note: FS is the foreign share (in percent) of industry shipments and F4 is the foreign share (in percent) of the shipments of the leading four firms in each industry.

a/ Data for 170 industries that registered exports.

Transnationals control all four leading firms in only four industries: electrical generating equipment, automobiles, paints, and pharmaceutical products. The remaining 103 industries fall between these two extremes. Details by subsector are reported in table 9.

There is a highly significant and positive correlation between the foreign share of industry shipments (FS) and industry concentration, confirming similar results reported in earlier studies of Brazil and other countries (Lall 1978, pp. 226-229 and Lall 1979). The Spearman coefficient of rank correlation between FS and the four-firm concentration ratio (CR4) is 0.252 for domestic sales and 0.244 for total sales, and the results are similar when concentration is measured by the Herfindahl (H) index. (See table 10.) Surprisingly, in export markets the correlation between foreign control and concentration is negative. The greater the presence of foreign-owned firms, the less concentrated are the exports of Brazilian industries.

Deleting the 42 industries with no foreign investment produces a substantial increase in the correlation between the foreign share of industry shipments (FS) and concentration. This is a result of the fact

Table 9. Distribution of 174 Manufacturing Industries by Foreign Share of Domestic Shipments of the Leading Four Firms, 1980.

Subsector	F4 - Domestic Sales			
	0	1-50%	51-99%	100%
Non-metallic minerals	1	1	2	--
Basic iron and steel	2	3	4	--
Basic non-ferrous metals	2	2	5	--
Metal products	2	4	1	--
Machinery	--	6	5	--
Electrical equipment	1	3	4	1
Transport equipment	3	4	2	1
Wood	4	2	1	--
Furniture	3	--	1	--
Pulp and paper	--	5	--	--
Rubber	3	2	1	--
Leather	1	2	1	--
Chemicals	3	5	5	1
Pharmaceutical	--	--	--	1
Perfumes and soaps	1	1	1	--
Plastics	3	--	4	--
Textiles	3	3	1	--
Clothing and footwear	3	2	--	--
Food products	16	5	3	--
Beverages	2	3	1	--
Tobacco	2	--	2	--
Printing and publishing	1	1	--	--
Other manufactures	11	1	4	--
TOTAL MANUFACTURING	67	55	48	4

Source: 1980 data base.

that in some of the most concentrated industries, such as toys and steel wire, there are no foreign-owned firms at all. For export sales in this subset of 132 industries, the correlation between FS and concentration is positive, but rather low and not statistically significant.

The association of high levels of foreign ownership with high levels of concentration is often taken as evidence that the former 'causes' the latter, but significant correlation need not imply causation. Both variables are elements of market structure, and both are likely affected by common factors such as technological change, product differentiation activities and scale economies, including the economies of multiplant operations. In addition, foreign ownership is more prevalent among the largest firms in each industry, and this fact alone can give rise to a

Table 10. Seller Concentration and Foreign Control (Spearman coefficients of rank correlation)

		FS	F4
All 174 Industries:			
Domestic Sales	CR4	.252**	.200**
	H	.240**	.189*
Exports a/	CR4	-.165*	-.115
	H	-.145	-.109
Total Sales	CR4	.244**	.174*
	H	.227**	.163*
132 Industries with Foreign Presence:			
Domestic Sales	CR4	.483**	.324**
	H	.464**	.311**
Exports b/	CR4	.160	.137
	H	.137	.112
Total Sales	CR4	.465**	.215*
	H	.448**	.281**

Source: 1980 data base.

Note: A single asterisk (*) indicates significance at the .05 level and a double asterisk (**) signicance at the .01 level in a two-tailed test. Foreign control is measured by the share of foreign-owned firms in industry shipments (FS) and by the foreign share of shipments of the leading four firms in each industry (F4). Seller concentration is measured by the four-firm concentration ratio (CR4) and the Herfindahl index (H).

a/ Data for 170 industries that registered exports.

b/ Data for 131 industries that registered exports.

correlation between foreign control and concentration. Consider, for example, the hypothetical case of four industries in which each of the leading four firms produce 10 units of output and a large 'fringe' of small firms is nonexistent in one industry, and produces a total of 10, 40 and 120 units respectively in each of the other three industries. Assume, in addition, that two of the four leading firms in each industry is under foreign ownership whereas the remaining firms are locally owned. The CR4 ratios and foreign market shares (FS) of each industry would be as follows:

	CR4	FS
industry 1	100	50
industry 2	80	40
industry 3	50	25
industry 4	25	12.5

The result is a perfect correlation between concentration and foreign control caused not by interindustry variations in foreign presence, but rather by the fact that foreign investment is confined to the upper portion of the size distribution of firms.

Rosenbluth (1970) presented evidence that the above artificial example is descriptive of Canada, i.e. that the size distribution of foreign firms is alone responsible for the high observed correlation between concentration and foreign control. Our data permit a direct test of the explanatory power of this hypothesis in Brazil. If the correlation between CR4 and FS is due solely to the greater size of foreign-owned firms, then one would not expect any significant correlation between the foreign share of sales of the leading four firms (F4) and industry concentration ratios. The statistics reported in the second column of table 10 suggest that this is not the case for Brazil. The correlation between concentration and F4 is somewhat lower than that between concentration and FS, but it is positive and significant at the five percent level regardless of whether shipments are measured by total sales or by domestic sales. Moreover, if the 42 industries with no apparent foreign investment are deleted, the correlation between concentration and F4 is much higher, and is statistically significant at the one percent level.

In sum, in Brazilian industries there is a positive and significant relationship between foreign control and seller concentration; moreover, this relationship is not due solely to the tendency of foreign firms to rank among the largest in each industry. This result is similar to that found for Guatemala in an earlier study (Willmore 1976, pp. 504-508). It differs from that found for Brazil by Bonelli (1980, pp. 868-874) using

rather aggregate 1973 and 1977 data, but it confirms the findings of Fajnzylber (1971, pp. 106-111) and Considera (1980, pp. 98-99).

Although a positive correlation exists between concentration and foreign control that is independent of the size distribution of firms, this does not necessarily imply that foreign ownership is a cause of high concentration. Factors other than the presence of foreign-owned firms affect concentration, and common factors may cause both high levels of concentration and high levels of foreign control. Another study (Willmore, in preparation) attempts to sort out and test these possibilities. The study concludes that foreign control is associated with high levels of concentration after controlling for other determinants of concentration. The welfare implications of the study are ambiguous, however, because the high concentration associated with high foreign control is a result of less suboptimal capacity, which is socially desirable, and fewer efficiently-scaled firms, which is not desirable.

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