Factor Content and Technology Service:

The Export Impact From Multinationals

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Abstract

We develop an industry-level model to examine the impact of multinational firms (MNFs) on revealed comparative advantages (RCA), predicting that it stems from firms' *technology service* and their *factor-content*. Based on Brazilian manufacturing industries during the import-substitution period, the panel data estimates show that *FORGN* (multinationals' share in industries) negatively affected *RCA*, due to *location advantages* in industries intensive in skilled labor; or else to horizontally integrated MNFs, shown by the estimates of firms' location model. To single out *technology service*, we insert the predicted *FORGN*, from the location model, into the trade (*RCA*) model, which shifts that coefficient to positive.

1. Introduction

Theoretical models of international trade models with multinational firms (MNFs), fully developed only the middle 1990s[1], inspired a wave of empirical works about the emergence and location of these firms around countries and industries (Brainard 1997; Norback, 2000; Hanson *et al.*, 2005). These applied general-equilibrium studies have not advanced, however, to the impact of MNFs on country's trade volume. Sleuwaegen & Backer's (2001) is an exception, although they do not theoretically develop the relationships underlying MNFs' activities.

Evidence is part of the difficulties in these studies around MNFs and trade volume. Any such an analysis must be connected to some sort of industry-level data, which turns data collection too difficult within a multi-country framework based on firm-level data, as the above commented. Modeling is another source, since the two-sector theoretical models, with multinationals operating in one industry alone, shed no-precise guidance as to the impact of MNFs activities on domestic resources allocation in an *N-industries* economy. Bear in mind that, in the real world, distinct MNF types may underline the presence of these firms across the industries, giving no definite answer as to their impact on trade volume.

In the present paper, we develop a theoretical framework to empirically analyze the impact of multinational firms on trade (exports) volume. It is an industry-level model, concentrated in one host country, which greatly draws on Markusen &Venables (1998 – M&V henceforth) and Zhang & Markusen (1999), regarding the impact of industries' production regimes (the output share of multinational and national firms) on trade volume. All developments aims to lay down the idea that the impact of foreign affiliates would be related to both the factor content of their activities – the industry they operate – and their specific

[1] Including distance (transport-cost). See Markusen (1984), Helpman (1984), Ethier (1986), Brainard (1993), Markusen & Venables (1998), Ethier & Markusen (1996), and Zhang & Markusen (1999).

technology service, which can ultimately be referred to the type of incoming MNFs (vertically, horizontally or mixely integrated).

From a monopolistic competition structure, we attain a trade model in which revealed comparative advantages (*RCA*) is determined by *world income elasticity, comparative marginal cost,* and *international competition.* Fixed costs, unfolded into firm-specific technology (*F*) and plant (*G*) cost, create the opportunity for multinational firms, as developed in a location model. Econometrically specified, this model will help us to characterize these firms' type, given countries' advantages. Moreover, this location model enables us to attain the amplified export model in which *F,* associated with skilled labor, is particularized by firm type, and so the impact of MNFs stems from (i) technology service and (ii) factor-content.

To untangle each of these two impacts, concealed in the unique coefficient of the production regime upon *RCA*, we resort, firstly to a descriptive statistical analyses about the location pattern of foreign affiliates, and lastly to the endogenous theoretical relationship between the location and the trade model: using the predicted values from the former so that its impact on *RCA* boils down to the technology service.

The panel data are based on large and protected less developed countries (LDCs), Brazil, whose market size and abundant unskilled labor attract both *horizontal and vertical* MNFs. More to the point, we take Brazil during its import-substitution industrialization – the leading FDI's (Foreign Direct Investment) receptor among LDCs in that period[2] - with respect to a set of six developed countries, covering twenty manufacturing industries over four years from the late 1960s to the late 1980s.

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[2] Hosting 11.3% of all inward FDI stock in developing economies in 1967, and 16.4% in 1983 (Jenkins, 1987; Appy, 1987. Net FDI inflow, for 1968-82, was: US$ 14 billion to Brazil, US$ 7 billion to Mexico, US$ 3 billion to Hong Kong, and US$ 648 million to Korea (Bruton: 1989). Thanks *inter allia* to a strategy combining strong trade protectionism with fair liberalism to international companies (Fritsch & Franco, 1994).

The paper is structured as follows: models are worked out in Section 2. In Section 3, we describe the variables and, in Section 4, we show and interpret the estimations.

2. Export Contribution by Multinationals: Theory and Empirical Specification

2.1 Trade Model

Consider an integrated economy producing a homogenous agricultural goods, *g,* with unskilled labor and under constant return to scale, and various differentiated manufactured goods, *m,* with both unskilled and skilled labor and under increasing returns.

Consumers' preferences follow the function:

$$U = \sum_i X_{m,i}^{\pi_i} X_g^{1-\pi_m} , \tag{1}$$

where X stands for the consumption (sales) of each product and the superscripts for their respective share in total consumption, with $\pi_m = \sum \pi_i$ of each manufactured goods (industry) *i.* Given budget restrictions, the demand for each manufacturing industry will be:

$$X_i = \pi_i Y \left(\frac{1}{p_i} \right) , \tag{2}$$

Y is the aggregate income of consumers and p_i the relative price of manufactured goods *i*.

Consumers' preferences for varieties of manufactured goods *i* follow a subutility CES (constant elasticity of substitution) function for *love of variety,* so that price-elasticity of demand $\sigma = (1/1\text{-}\theta)$ equals the elasticity of substitution among varieties, when firms have a negligible effect on the marginal utility of income (Helpman & Krugman, 1985, ch. 6). And the monopolist optimum price, $p_i = \theta c_i$, c_i being the marginal cost (with unskilled labor), is such that the markup θ covers only the fixed costs: profits are zero in the long run. Substituting this p_i into (2):

$$X_i = S_i \left(\frac{1}{\theta_i c_i} \right), \tag{3}$$

where $S_i = \pi_i Y$ is the price-independent component of industry size, S_i. Varieties have the same demand and prices, but not the distinct goods, as the i_s indicate.

Changes in output composition are a fundamental characteristic of economic development. We associate it with non-homothetical preferences as income changes over time, $\pi_{it} = \pi_i(Y_t)$, which enables us to express S_{it} in terms of income-elasticity of demand, η_i:

$$X_{it} = Y_t^{\eta_{it}} \left(\frac{1}{\theta_{it} c_{it}} \right), \tag{4}$$

$Y_t^{\eta_{it}}$ coming from $dlogS_{it} = \eta_{it}\, dlogY_t$. Since η_{it} varies with time changes in Y alone, the well-behaved form of utility function (1) is assured. This time-conditioned *Engel's law* introduces a term for structural change in output composition that is irrespective of prices.

Total sales $X_t = \Sigma X_{it}$ have a fixed proportion to total income, Y_t, so normalizing (4) by X_t and then linearizing it, yields the following stochastic equation:

$$x_{it} = \alpha_0 + \alpha_1 \eta_{it} - \alpha_2 (w_t a_{it}) - \alpha_3 \theta_{it} + \upsilon_{it}, \tag{5}$$

where $x_{it} = X_{it}/X_t$ is the relative sales of manufactured goods i at time t, υ_{it} is the random error and $w_t a_{it} = c_{it}$, since marginal cost refers to unskilled labor. Therefore, x_{it} vary according to income-elasticity of demand, marginal cost and its markup.

We now shift to an international market equilibrium with unequal factor rewards by, firstly, assuming identical preferences worldwide, which refers us to a corresponding equation (5*) for the foreign economy, and, secondly, making x_{it} and x^*_{it} stand for Brazil and foreign economy sales for the world – a three-country model. Finally, the price-independent term, S_i, is replaced by international industry size, $S_i^w = \delta_i (Y_t^w)^\eta$, where δ is the local economy share in the world sale of i and Y^w is the world income. Dividing (5)/(5*) yields the international equilibrium in which x_{it}/x^*_{it}, the *revealed comparative advantages* (RCA), according to Balassa (1965), are determined by comparative exporting conditions of the local economy:

$$x_{it} / x_{it}^{*} = \beta_{1i} + (\delta_i - \delta_i^{*})\eta_{it} - \beta_3 \left(\frac{w_t a_{i,t}}{w_t^{*} a_{i,t}^{*}} \right) - \beta_4 \theta_{it} + \mu_{it} \, . \quad (6)$$

β_{1i} is a specific-industry intercept, and μ_{it} the random error. A set of developed countries, taken as an integrated economy, will represent the foreign economy and, given trade restrictions, θ_{it} now carries positive profits, or tariff revenue (Sen, 2005). Variable η_{it} stands for changes in the world market demand in each *i* industry, so (δ_i - δ_i^{*})>0 would mean that Brazil advanced its world share in the most demand-dynamic industries, which can be assigned to international learning (Passinetti, 1993), or to *human capital* formation (Currie *et al.,* 1999).

2.2. Multinationals Firms

The fixed costs encompass plant costs, *G,* and firm-specific research costs, *F,* making room for multinational firms. Two issues immediately arise for the international equilibrium: (a) in which countries and industries will MNFs occur? and (b) what is their effect on hot-country international trade pattern and volume?

Multinational firms mainly arise in industries intensive in non-rival inputs (*F),* related to research activities, that can be used in new plants with no additional costs, or just a marginal fraction related to technology transfer. The types of integration between parent and affiliate units are related in turn to plant costs: horizontal integration occurs in large foreign markets that lower the fixed cost *G* of subsidiaries as compared to export cost from a local plant [$G+\tau$ (transportation-cost)], whereas vertical integration occurs in countries whose differences in factor prices push the marginal plant costs significantly down.

Accordingly, the basic relationships determining the production regime X_f^{hm}/X^n (the mix of foreign multinationals and national firms' output in industry *X*) for horizontal integration can be expressed by this slightly modified version of Brainard's (1997) equation:

$$\frac{X_f^{hm}}{X^n} = \frac{w^s F}{w^s G.e^{-S(1+T)(1+\tau)}} \qquad (7H)$$

The fixed-cost ratio F/G_h is the *industry effect,* making X more or less intensive in multinationals, whereas the remaining variables stand for the *location effect* (Hwang & Mai, 2002): host market size S in reducing the G cost, whereas the import barriers, $T,$ and the transport-cost (from source-country), $\tau,$ increase the relative cost of exporting from the source country. Skilled labor price, w^s, fulfills the list of the location effect, conventionally called *location advantages* (Dunning, 1981).

In vertically integrated plants, T and τ have an opposite result: they increase the overseas processing costs, while S helps to reduce the cost of product shiped back to parent firm (Zang & Markusen, 1999). The F/G ratio still gives an edge to multinationals, but foreign plants are no longer intensive in F and the G cost is based on unskilled labor. Hence, the production regime of vertically integrated foreign firms, X_f^{vm}/X^n, is driven by:

$$\frac{X_f^{vm}}{X^n} = \frac{w^s F_v}{w.G_v.e^{(1+T)(1+\tau)-S}} \qquad (7V)$$

Since X_f^{vm} is related to another production phase, $G_v \neq G$ (of the parent firm), whereas $F_v < F,$ translating the low intensity in skilled labor and referring to technology transfers to foreign plants.

As implied, $X^{mf}/X^n = \phi(X_f^{hm}/X^n) + (1-\phi)(X_f^{vm}/X^n)$, for $\phi \in [0,1]$. Hence, the weights of each MNFs-type in the aggregate production regime, X^{mf}/X^n, will condition its effect on host country trade (export) volume, as developed next.

The chosen period of our panel data prevents full information on technologies and factor prices. Yet, a good picture about w and w^s is given by the below data on factor endowments in Brazil relative to the then six major developed countries (the USA, Japan, Germany, the UK, France and Italy)[3], taken as the foreign economy. As shown in Table 1, Brazil's relative abundance of both unskilled labor and land was maintained from 1967 to 1980.

Hence, Brazil's size (among the then world's ten largest economies), import barriers and large distance represent strong *location advantages* to horizontal foreign affiliates, whereas vertical MNFs are discouraged by the same high τ and T – despite factor prices (including resources) – for increasing the local processing cost. In fact, exports by foreign affiliates in Brazil amounted to only 7.9% of their total sales in 1973, and to 10.1% in 1980 (Doellinger & Cavalcanti, 1979; Cepal, 1983)[4].

Table 1: Factors Endowments – Brazil/Developed Countries

	Skilled/Non-Skilled Labor*		Skilled Labor/Land **	
Countries	1967	1980	1967	1980
Brazil	0.05	0.08	0.08	0.21
Developed Countries	0.11	0.17	0.41	0.44

Sources. Labor for Developed Countries: 1967: Bowen et al (1987); 1980: Trefler's (1995) database (http://www.nber.org/ftp/trefler/HOV). Labor for Brazil: IBGE, *Anuário Estatístico do Brasi*l Land: 1967: Bowen et al. (1987) and World Institute Resource (1998), World Resources 1998-99.
* Technical & Professional/Remaining economic occupation. ** Land: cropland and pastures in hectares.

Relying on (7*H*) for a general stochastic specification of (7) yields the following linear equation, after adjustments to available data:

$$\frac{X_{it}^{mf}}{X_{it}^{n}} = \alpha_{1t} - \alpha_2 \eta_{it} - \alpha_3 \bar{G}_{it} + \alpha_4 \frac{Y_{it}}{Y_{it}^{*}} + \alpha_5 T_{it} + \alpha_6 \frac{w_t a_{it}}{w_{it}^{*} a_{it}^{*}} + \varepsilon_{it}\,, \tag{8}$$

where ε_{it} stands for the stochastic errors, $\bar{G}_{it}$ for plant-based economies of scale, Y_{it} / Y_{it}^{*} for relative industry size, and T_{it} for the import barriers.

[3] They accounted for 71.6% of the inward FDI stock in Brazil in 1977 (Cepal, 1983).
[4] Although inward-orientation dominated the Brazilian manufacturing industry: 8.1% export propensity in 1979 (Cepal, 1983).

The knowledge capital F identifying horizontal MNFs is proxied by η_{it}, given their negative on world trade volume (M&V). For vertical integration, α_2 may instead take positive value on the ground that it would facilitate international market access (UNCTAD, 2002; Zhang & Marksuen, 1999), although F is fixed in (7V). The comparative marginal cost, $w_i a_{it}/w_i^* a_{it}^*$, captures the search for marginal (comparative) costs in the case of vertical integration, although a two-factors technology would be more accurate.

Local market size (Y_{it} / Y_{it}^*) attracts both vertical and horizontal integration, but economies of scale at plant size ($\bar{G}_{it}$) is negative for X_f^{hm}/X^n, given that G_h=G, and undetermined for X_f^{vm}/X^n.

2.3. Multinationals and Exports

We now consider the impact of the production regime, X_{it}^{mf} / X_{it}^n, on trade volume. Taking both F and G in aggregated form – *i.e.*, disregarding their composition as to multinational and national firms – then the equilibrium price in industry X, becomes:

$$p_x = \frac{w^s F}{X} + w\left(\frac{G}{X} + a\right), \tag{9}$$

under zero profits due to free entry.

Substituting (9) into the Marshallian demand (2), as done before to reach (6), we obtain the relative international sale of domestic industry X:

$$x / x^* = \beta_{1i} + (\delta - \delta^*)\eta - \beta_3\left(\frac{w\ a}{wa^*}\right) + \beta_4\theta + \beta_5\overline{G} - \beta'_6\ F + \upsilon\ , \tag{10}$$

where $\overline{G}$ stands for fixed plant costs, F for the knowledge-capital, and θ was introduced by relaxing the assumption of zero profits. Given the scarcity of skilled labor in developing countries, $\overline{F}$ negatively affects the comparative advantages of the technology intensive X industry, relatively to the agricultural sector.

Multinational and national firms are distinguished by the assumption that $F^m<F^n$, underlying (7) and expressing the former ownership advantages: from MNFs being able to spare much of the F cost in subsidiaries. So, as for equation (10):

$$\frac{dF}{d(X_f^m / X^n)} < 0 = \beta_6 \,. \tag{11}$$

Hence, higher X_f^m/X^n have a positive β_6 ($\neq\beta_6'$) impact relative export (x/x^*), which stands for MNFs' technology services. And this holds true for both X_f^{hm}/X^n and X_f^{vm}/X^n.

Nonetheless, once comparative exports in (10) are defined over n industries, then the export impact of X^m/X^n also depends on cross-industry orientation of multinationals, or else on firm-type. From (7*H*), the share X_f^{hm}/X^n rises as we move to F (i.e., R&D, marketing and managerial) intensive activities, whereas from (7*V*) the relationships is either null or negative:

$$\frac{dF_i}{d(X_f^{hm} / X_i^n)} > 0 = \beta_7 \quad (12.1); \qquad \frac{dF_i}{d(X_f^{vm} / X_i^n)} \leq 0 = \beta_7^{'} \quad (12.2)$$

That is, the value of intangible asset F increases as we move towards industries intensive in horizontally integrated multinationals – a *stylized microeconomic fact* (Markusen, 1995) – leading to a negative impact on comparative advantages, given Brazil's endowments of skilled labor[5]. On the other hand, F cost is non-increasing with respect to X_f^{vm}/X^n, as shown in (12.2), so that it leads to either a null or positive impact on host-country's relative exports. Therefore (12.1)-(12.2) indicate how *location advantages* linked to either *market proximity* or *factor proportions* affect relative exports in a large and unskilled-labor economy.

Taking (12.1) as a benchmark, the now n industries export model with multinationals becomes:

$$x_{it} / x_{it}^* = \beta_{1i} + (\delta_i - \delta_i^*)\eta_{it} - \beta_3 \left(\frac{w_t a_{i,t}}{w_t^* a_{i,t}^*} \right) + \beta_4 T + \beta_5 \bar{G}_{it} + (\beta_6 - \beta_7)\frac{X_{it}^{mf}}{X_{it}^n} + \mu_{it} \,. \tag{13}$$

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[5] Its export impact is unrelated to the omitted transport cost τ, in (8), since τ can be bad for exports to source countries, but not to third countries (Kumar, 1998).

Having accounted for both *G* and *F,* then the remaining term of the markup $\theta = \theta(n, G, F)$ can be proxyied by *T,* import barriers, where *n* stands for the number of firms, or else for the market power. That is, *T* proxies the positive profits, thus bearing a correspondence with the *competition effect* of international trade (Helpman & Krugman, 1985).

Both (8) and (13) describe the international location of production: (8) for distinct types of firms and (13) for countries as manifested by the comparative trade volume.

Noticing that a theoretical variable, *F,* is represented by distinct empirical variables: in (8) it is explaining the location of multinational firms according to their types, whereas in (13), we have the impact of *F* on exports particularized by multinational as to national firms, with the coefficient conditioned to the dominant MNFs' type.

Nonetheless, the qualitative impact of multinationals on exports, given by $(\beta_6 - \beta_7) \gtrless 0$, falls short of a conclusive prove about the dominant MNF-type, showing up the difficulty of industry-level data, as X^{mf}/X^n to find out what type of international firm dominates X^{mf}. However one can overcome this data problem by theoretical modeling. Replacing the exogenously given X^{mf}/X^n by its endogenously predicted value, $\left(\widehat{X_{it}^{mf}/X_{it}^{n}}\right)$, from (8), (13) can be re-written as:

$$x_{it} / x_{it}^{*} = \beta_{1i} + (\delta_i - \delta_i^{*})\eta_{it} - \beta_3 \left(\frac{w_t a_{i,t}}{w_t^{*} a_{i,t}^{*}} \right) + \beta_4 T + \beta_5 \bar{G}_{it} + \beta_6 \left[\widehat{X_{it}^{mf}/X_{it}^{n}} \right] + \mu_{it} . \tag{14}$$

Here β_7 drops out from the fact that (8) describes the industry location of foreign multinationals, so their impact on domestic resource allocations, which becomes controlled when using the endogenous predicted production regime. In short, (14) tests only MNFs' technology service and is obtained from two stage estimations – $E\{y_2 | x_2, \theta_2, E[y_1 | x_1, \theta_1]\}$ – as shown below. We also show that some variations in (8) permit to control part of the β_7 effect.

Besides the comparison between models (13) and (14), the empirical analysis around the X_{it}^{mf}/X_{it}^{n} will also encompass: (i) the estimates of the production regime model (8) and (ii) a descriptive analysis around its cross-industry variation according to their technology.

3. Data and Variables

Let us transform (13) to a named form:

$$RCA_{it} = \alpha_i + \beta_1 YEL_{it} - \beta_2 CPCOST - \beta_3 TAR_{it} + \beta_4 SCALE_{it} + (\beta_5 - \beta_6) FORGN_{it} + \mu_{it}\,, \qquad (15)$$

where the revealed comparative advantages $RCA_{it}=x_{it}/x_{it}^{*}$, $YEL=\eta_{it}$, $TAR_{it}=T_{it}$, *SCALE* stands for *G,* and $FORGN_{it}=X_{it}^{mf}/X_{it}^{n}$. Inasmuch as w_t/w_t* is unique in each period *t*, not altering the ordering and variation of cross-industry $CPCOST_{it}=w_i a_{it}/w_i^{*} a_i$, we may substitute it by comparative productivity, $CPROD_{it}=a_{it}/a_{it}^{*}$, for reasons expounded below. The predict values of $FORGN_{it}$ in (14) is named $PREDICT_F$.

The known dearth of international data becomes more stringent within this *cross-section time series*, namely for technologies and factor endowments (or prices) of all countries, industries and periods simultaneously. Here, the panel data variables cover twenty industries – ISIC at three digits, adjusted to standard classification for $FORGN_{it}$ – and four periods (1967, 1973, 1980 and 1987-88), with slight deviation in time for some variables. Sources are found in the Data Appendix. The then six largest industrialized economies (the USA, Japan, Germany, the UK, France, and Italy), taken as an integrated economy, represent the foreign economy.

Hence x_{it}/x^{*}_{it} is such that $x_{it}^{*} = \Sigma_{ij}(X_{it}^{j}/X_{t}^{j})$, where X^{j}_{it} stands for each *j* country's exports of industry *i* at time *t,* and X^{j}_{t} for its total manufacture exports.

Variable $\eta_{it} = YEL_{it}$, standing for worldwide income-elasticity of demand, is given by:

$$\eta_{it} = \frac{X_{it}^{w} / X_{i,t-1}^{w}}{Y_t^{w} / Y_{t-1}^{w}},$$

where X_i^w is the world's exports of industry *i* and Y_t^w is the world total exports of all industries (i.e., not only manufacturing). Y_t^w could be expressed by the world *value added* of tradable goods sectors, but it was not available, so we used the output of tradable sectors sold internationally. Since data of X_i contains production input, η_i encompass both the *Engls law* and biased technology changes.

Regarding *CPCOST*, the productivity term is $a_{it}=l_{it}/y_{it}$: "*total employees* (except working proprietors, active business partners, unpaid family workers and homeworkers)/*value added*". In the foreign economy, $a_{it}^{*} = \Sigma_j l_{it}^{j} / (\Sigma_j y_{it}^{j})$. Given that manufacturing industry wages were not available in compatible form in the six countries over all periods, then *per capita GDP* represents both *w* and *w**, as in the Ricardian *n goods* model (Dornbusch *et al.*, 1977), with w_t* standing for the weighed average *per capita* GDP of the six developed countries.

Certainly, the unobserved factor endowments among countries influence the labor technology (a_{it}/a^{*}_{it}), given that labor directly engaged in production (mostly unskilled) dominates total labor employment in the industries. However, from Helpman & Krugman (1985: 24-28), one can say that the bias would be about the same in the *n* industries; that the industry ordering (a_{it}/a^{*}_{it}) is not strongly affected.

SCALE = value added/number of employees in each *i, t* of the integrated foreign economy, is a general measure of economies of scale, which Brainard (1997) reported as similar to her measure of corporate economies of scale. Taking $SIZE_{it} = y_{it} / \sum_j y_{it}^{*}$ as the relative host-industry size, we also compose $GSIZE(SCALExSIZE) = y_{it} / \sum_j l_{it,j}^{*}$, a proxy for plants cost adjusted to the host country size.

TAR_{it} is the *effective rate of protection* in Brazil; nominal tariffs, $TNOM_{it}$ are also considered. Not accounting for tariffs in the foreign economy, due to lack of corresponding panel data, is tantamount to assuming that the manufacturing industry in this region operated as if under free trade, compared to Brazil – a reasonable hypothesis for the period. Finally, $FORGN_{it}$ stands for foreign affiliates' output share in industry *i* at *t* (see Appendix).

4. Empirical Results

All beta coefficients the *fixed effects* (FE) estimators of (8) and (13) are statistically significant, against only one in the RE model, indicating that the α_i are not randomly distributed; *i.e.*, that they inform industries' particular characteristics[6].

Rather expected from the panel dimension (see Green, 2000). We also applied the Weighted Least Squares estimators with White robust covariance – White test rejected the homoscedasticity of residuals at 1.0% of significance.

Table 2, below, reports the estimates of the location model (8) thus organized: models in columns (i)-(v) use *SCALE*, substituted in columns (vi)-(vii) by *SCALBR*, adjusted to Brazil's size. Lastly, *TNOM* replaces *TAR* in columns (vii)-(viii).

CPCOST and *CPROD* are statistically insignificant in all of them and have positive signs – except *CPROD* in column (vi) – which means that local marginal (production) costs did not drive foreign affiliates; against the hypothesis of *factor proportions* underlying vertical integration. The negative and statistically significant coefficient of *SCALE* [columns (i)] reinforces the opposite hypothesis of *market proximity*; that economies of scale at plant do not favor foreign production as compared to exporting cost – see also Brainard (1997).

[6] The Hausmann test for fixed against random effects could not be applied because the estimated covariance matrix of its coefficients is not positively definite – a not-so-rare result in small samples (Verbeek, 2000).

Table 2 - Estimates of the Production Regime Equation

Independent Variables	General Scales					Scales in Brazil		Nominal Tariffs	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
YEL	-0.016**	-0.024**	-0.023*	-0.022	-0.021	-0.018	-0.021	-0.029	-0.025
	(-1.810)	(-4.722)	(-4.457)	(-4.827)	(-4.175)	-2.875	(-3.200)	(-5.199)	(-3.741)
CPCOST		0.008		0.015		0.005		0.034	0.007
		(-0.525)		-1.284		-0.213		-1.012	(0.259
CPROD	0.007		0.001		0.003		-0.003		
	-1.000		-0.264		-0.506		(-0.675)		
SCALE	-0.001**	0.00	0.00	-0.001	-0.001			0	
	(-1.855)	-0.866	-0.063	(-2.812)	(-2.762)			(-0.156)	
SCALBR						-0.001	-0.001		-0.001
						(-2.042)	(-2.000)		(-2.278)
SIZE		0.750*	0.7706			0.528			
		-7.498				4.656			
GSIZE				0.043	0.04		0.033	0.028	0.017
				-13.33	-12.165		-11.168	-4.478	-2.686
TAR	-0.036*	-0.037*	-0.038	-0.039	-0.04	-0.038	-0.031		
	(-5.099)	(-11.166)	(-9.138)	(-9.282)	(-7.472)	(-12.174)	(-9.405)		
TNOM								-0.025	-0.019
								(-3.159)	(-3.180)
N. Obs.	77	77	77	77	77	77	77	77	77
Adjusted R^2	0.964	0.989	0.989	0.994	0.993	0.987	0.992	0.976	0.98
F-statistics	685.8	1,759.20	1724.4	3,432.20	2,629.50	1,442.20	2,278.00	1,035.80	958.9

Dependent Variable is *FORGN*. Numbers in parentheses are *t statistics*.
The simbols (***), (**) and (*) indicate statistical significance at 10%, 5% and 1%, respectively

Nonetheless, *SCALE* shifts to positive and becomes positive, when *SIZE* is added [columns (ii)-(iii)]. Inasmuch as the positive *SIZE* is compatible with both vertical and horizontal integration, the above conclusion about *SCALE* no longer holds good in an ampler model. Replacing *SIZE* by *GSIZE* (columns iv and v), standing for the impact of host-economy size in reducing local plants fixed costs we notice that *GSIZE* yields the predicted value and that *SCALE* shifts to negative and statistically significant. And here [columns (iv) to (v)], controlled for a better measure of economies of scale at the host-country plants, *SCALE* stands more clearly for the intended general measure of economies of scale at each industry, corroborating that the share of multinationals across industries varies according to the horizontal integration type. It is worth noticing that in all models, *GSIZE* yields higher goodness of fit (penultimate line of Table 2) than *SIZE*. A last variation is replacing *SCALE* by *SCALBR* [columns (vi)-(vii)], as allowing for technology differences in fixed costs, with either *SIZE* or *GSIZE,* one notices that this new variable for economies at scale at plant level is also negative and statistically significant – reinforcing the preceding conclusion.

Recall, from (7), that the impacts of both *SIZE* and SCALE cannot be divorced from the unobserved transport-costs (distance)[7]: the larger is τ, the more relevant are those variables.

TAR and *TNOM* are both statistically significant, but their negative signs, slightly greater for *TAR,* contradict the *tariff-jumping* hypothesis of horizontal integration. Its rejection, suitable in a multi-country analysis, is however at odds with the noticed tiny exports of MNFs in Brazil. The most tenable is that, in a large and highly protected economy, horizontal multinationals do not necessarily operate in the most protected sectors (tariffs concerned); that levels above 60% – the average, in the present case – are not in their interest[8]. There are also the effects of other (unobserved) barriers to foreign firms (e.g., the local content requirement).

Lastly, the negative coefficient of *YEL,* in all equations of Table 2, shows that multinationals concentrated in sectors with the least international market sale dynamism, matching prediction of purely horizontal multinationals on world trade, related to trade substitution, although it contradicts other analyses relating export dynamism in LDCs to multinationals (UNCTAD, 2002), more suitable to vertical integration, as noticed before. Hence, country's size, distance, and trade regime condition the subsidiary types and thus their trade impact. In fact, some of the activities horizontally integrated in Brazil were vertically integrated elsewhere, especially from the 1990s onwards (see Hanson et al, 2005).

[7] In Belgium, small size and low transportation cost (short distance and good railroads), led to vertical-MNFs and thus to their positive impact on *RCA* (see Sleuwaegen & Backer, 2001).
[8] So MNFs would not be the main actors behind the highest tariffs – distinct from the USA (Blonigen & Fligio, 1998); compatible with the model's causality, where firms are *tariffs takers*.

To examine the export consequence of this location of foreign affiliates we now estimate model (13) with the exogenous *FORGN,* since the residuals of (8) and (13) are not correlated (see Green, 2000) at 10% of statistical significance.

As shown in Table 3 below, all independent variables of the *RCA* model are statistically significant, where each specification are in pairs (of columns): one for *CPCOST* and the other for *CPROD*. The negative sign of YEL_{it} shows that the country did not throve in industries in the most sale-expansive world market, as if the country failed in comparative international learning (Pasinetti, 1981) – predictable from its poor formation of skilled labor.

Table 3 - Estimates of the RCA Equations

Variables	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
YEL	-0.069*	-0.070*	-0.057*	-0.061*	-0.055*	-0.058*	-0.045*	-0.054*
	(0.006)	(0.005)	(0.008)	(0.0073)	(0.0068)	(0.007)	(0.0057)	(0.006)
CPCOST	0.128***		0.0945***		0.08**		0.145*	
	(0.058)		(0.051)		(0.041)		(0.045)	
CPROD		0.076*		0.081*		0.084*		0.082*
		(0.013)		(0.018)		(0.016)		(0.018)
SCALE	0.010*	0.009*	0.005*	0.003*	0.005*	0.003*	0.005*	0.003*
	(0.0009)	(0.0009)	(0.001)	(0.0012)	(0.0009)	(0.001)	(0.001)	(0.001)
SIZE			-2.078*	-2.059*	-2.558*	-2.178*	-2.721*	-2.46*
			(0.375)	(0.362)	(0.337)	(0.364)	(0.303)	(0.345)
TAR	-0.102*	-0.095*	-0.088*	-0.072*				
	(0.017)	(0.012)	(0.022)	(0.02)				
TNOM					-0.087*	-0.071**		
					(0.020)	(0.032)		
FORGN	-1.011	-0.992*	-0.976*	-0.871*	-0.848*	-0.852	-0.701*	-0.688*
	(0.15)	(0.146)	(0.203)	(0.199)	(0.173)	(0.189)	(0.169)	(0.174)
N. Obs.	77	77	77	77	77	77	77	77
Adjusted R2	0.504	0.517	0.572	0.525	0.610	0.528	0.567	0.526
F-Statistic	25.27	26.34	25.35	21.81	28.79	22.02	30.87	27.08

Note: Dependent Variable is RCA
Numbers in parentheses are standard errors.
The simbols (***), (**) and (*) indicate statistical significance at 10%, 5% and 1%, respectively

The most striking result is the positive coefficient of both *CPCOST* ($w_t a_{it}/w_t a_{it}^*$) and *CPROD* (a_{it}/a_{it}^*) in all pairs of equations, as if higher comparative costs (and labor input) lead to greater comparative exports, expressing a sort of *inverted markets* (i.e, extreme inefficiency). Inasmuch as *TAR* controls only part of Brazil's trade policy, this result can be attributed to remaining instruments (quantity controls and the huge export subsidies) that pushed resources towards the less efficient industries (Moreira, 1995; Savasini, 1983)[9].

The positive coefficient of *SCALE* shows that Brazil's *RCAs* were proportional to economies of scale, though at a very small level, whereas the largely negative *SIZE,* from columns (iii) on, shows that the relatively largest industries exports the least; a further inefficiency sign of its inward-orientated growth.

The coefficient of effective rate of protection, *TAR,* confirms the *competition effect*: protection refrains export competitiveness. On the other hand, nominal tariffs, *TNOM* is positive (columns vii and viii). The difference is that *TAR* accounts for the effect of protection and incentives on the markup, whereas *TNOM* measure of barriers to each good. In short, *TNOM*, together with other policy instruments, determine *TAR,* which is the best measure of income incentives, so negative conclusions concerning protection cannot be avoided.

Lastly, the negative sign of *FORGN* shows the singular effect of MNFs-intensive industries on exports. From our model, this means that $(\beta_5\text{-}\beta_6)<0$: affiliates *ownership advantages* were outweighed by *location advantages* opposed to the country's comparative advantages. From another standpoint: despite the impressive growth of MNFs exports in Brazil, from the 1960s to the 1980s (Blomstrom, 1990), the expansion of these technology-superior firms drew resources towards the least exporting industries. Noticing that the negative $(\beta_5\text{-}\beta_6)$ does not carry a corresponding welfare impact to host-country, for unlike the

[9] In a forthcoming pure trade analysis, we demonstrate that these coefficients of *CPCOST CPROD* indeed reflect *inverted markets.* A graphical analysis, which can be ordered to the authors, also a positive time correlation between the average values of panels RCA agains *CPCOST* and *CPROD,* corroborating the extreme microeconomic inefficiency of this industrization (see Bruton, 1989).

competitive model under protection by Brecher & Diáz-Alejandro's (1977), β_7 is now endogenous to the economy – *TAR* is also controlling for trade policy[10].

Additional evidence are provided in the below contingence Table 4 of the time average of $FORGN_{it}$ against their RCA_{it} and technology pattern (from Lall, 2000). The industries are placed in decreasing order as to their *RCAs,* the values of which are repeated in column (i), whereas (ii) and (iii) give the ordinal and cardinal values of *FORGN*.

Table 4: Export Performance, Multinationals Shares and Technology

	RCA Value (i)	MNFS Share* Rank (ii)	MNFS Share* Value - % (iii)	Technology[¥] Classification (iv)
1. Food Products	6.41	14th	19.1	RB
2. Wood & Cork	3.02	17th	5.1	RB
3. Leather & Furs	1.72	13th	19.6	LT
4. Clothing & Shoes	1.23	18th	4.3	LT
5. Pulp & Paper	1.16	12th	20.4	RB
6. Metals	0.71	10th	26.9	LT
7.Textiles	0.65	15th	15.9	LT
8. Rubber	0.40	2nd	75	RB
9.Chemicals	0.30	6th	46.4	MT
10.Plastics	0.28	8th	34.6	MT
11.Other Chemicals(a)	0.28	4th	68	HT
12.Transport Equipment	0.27	3rd	68.5	MT
13.Mechanical Equipment	0.25	7th	40.7	MT
14.Beverages	0.23	16th	12.1	RB
15.Non metallic mineral	0.22	11th	25.4	RB
16.Furniture	0.18	19th	2.4	LT
17.Printing & Publishing	0.16	20th	1.9	MT
18. Tobacco(b)	0.15	1st	87.5	MT
19.Electrical Materials	0.13	5th	54	HT
20.Other Sectors	0.07	9th	33	HT

[¥]Resource Based (RB), Low Technology (LT), Medium Technology (MT), High Technology (HT).

(a) Given that, in Lall (2000), Pharmaceutical is classified as HT-2 and Cosmetics as MT-2.

(b) Different from Lall, who classified manufactured Tobacco as RB, since the world's two leading international firms run this industry, whose products present high level of technology exclusivity.

As can be seen, foreign affiliates' shares are very low in the seven first exporting industries, as well as quite high in the three worst exporting industries. Moreover, from column

[10] Entry of MNFs, even if oriented towards industries under comparative disadvantages, can cause large reduction in imports, as expound in M&V.

(i), we also see that the exporting levels of first industries, namely the first four, are far ahead of the remaining ones.

In short, *factor proportions* were not the dominant reason for incoming multinationals, but rather *market proximity*. Column (iv) gives more incisive evidence: the best exporting industries (Food Products, Wood, Tobacco, Leather & Furs, Clothing, Pulp & Paper, Metals, and Textile) are intensive in either resources or in unskilled labor (LT), whereas MNFs operate in either Medium or High-Technology industries (Tobacco, Electrical Materials, Transport Equipment, Other Chemicals, Chemicals, Non-Electric Machinery, Others). In sum, their anti-export pattern in Brazil witnesses horizontally integrated affiliates that, at the same time, are skilled-labor intensive. As the estimates of model (8) showed, the *location advantages* for these foreign affiliates can be assigned to both economies of scale and market size, the effects of which are amplified by distance (transport-cost). Legal restrictions against MNFs in mineral-related sectors cannot be disregarded, nor the smaller advantages of foreign production therein.

By eliminating the controls *TAR* or *TNOM,* as in the last two columns of Table 3, we can reach their singular effect upon MNFs' export impact. Surprisingly, *FORGN* becomes more positive, as compared to the original model in columns (i)-(ii), which means that protection is a positive element behind the comparative export contribution of foreign subsidiaries. In reality, the correct interpretation is that the negative effect of *TAR* hit national firms more severely than the multinational ones, which can be attributed to the fact that export subsidies (within *TAR*) benefited foreign affiliates mostly (Willmore, 1985). However, the same result is observed with *TNOM* [see columns (vi) and (viii)], in a smaller dimension though, which calls for an additional explanation. The most tenable: import tariffs hit more severely industries with comparative advantages, where national firms were concentrated.

Noticing, though, that protection in Brazil included instruments other than both *TAR* and *TNOM*.

Notwithstanding this full characterization of the factor content and trade pattern of *FORGN,* we have not single out the technology service by MNFs in the export model (13), as given by parameter β_6. We cannot tell, therefore, whether these firms present ownership advantages over same-industry domestic firms[11]. However, exploring the theoretical interaction between the endogenous determination of *FORGN* and its export impact we may attain such evidence: resorting to model (14), where *FORGN* is substituted by $PREDICT_F$ from model (8).

We applied a *Feasible TSLS* (Two Stage Weighted Least Square), manually correcting for heteroskedasticity in each stage[12], as with (8) and (13), given lack of a programmed routine in STATA 9.2. We restricted to the meaningful theoretical specifications of this TSLS, quite smaller than the possible combinations (*9x8*=162), given their commented estimation cost.

The main estimation results are displayed in Table 5 below. The first seven columns, we consider $PREDICT_F$ from the (8) location model without trade protection so as to capture the natural existence of MNFs; the exact specification of which is explained at the footnotes of Table 5. As the estimates show, in all these first seven specification of the export model (14), $PREDICT_F$ is positive and statistically significant – in the last one it is insignificant, though – as predicted. That is, controlling for the industry orientation with the endogenously determined production regime, the export impact of multinational shifts to positive. This is tantamount to saying that, on average, foreign affiliates have a superior impact on export volume than same-industry national firms, standing for the former technology service, as theoretically deduced.

[11] Even though Willmore (1985, 1987), using a distinct sampling – over 1980 only – and a partial equilibrium approach model did show it.

[12] By the variance of each group: $\sigma_i^2 = \sum (y_{it} - \hat{y}_{it})^2 / T_i$, where T_i is the number of observations in each group and $\hat{y}_{it}$ are the OLS fitted values.

Table 5 - Estimates of the Export Equations

		Predict$_F$-I$^{¥}$				Predict$_F$-II$^{¥}$		Predict$_F$-III$^{¥}$	
Variables	**(i)**	**(ii)**	**(iii)**	**(iv)**	**(v)**	**(vi)**	**(vii)**	**(viii)**	**(ix)**
YEL	-0.237**	-0.277**	-0.2198	-0.320**	0.0344	-0.0068	-0.4555	0.0673	-0.4400
	(0.1108)	(0.1137)	(0.183)	(0.122)	0.1280	(0.1328)	(0.2794)	(0.1354)	(0.0661)
CPCOST	-0.176**		0.7434	-0.1720	-0.245*		0.895*	0.986*	0.281**
	(0.0875)		(0.0844)	(0.1048)	(0.0986)		(0.168)	(0.103)	(0.1123)
CPROD		-0.0787				-0.0534			
		(0.0501)				(0.0549)			
SCALE			0.0058	0.0083	0.0235*	0.0233*		0.0145*	0.0147*
			(0.004)	(0.003)	(0.0011)	(0.0018)		(0.00113)	(0.00098)
SIZE							-3.245*		
							(0.4302)		
GSIZE	0.118*	0.1243*							
	(0.0269)	(0.0313)							
TAR			-0.008*		-0.0009*	-0.0014*	-0.0033*	0.0033**	
			(0.001)		(0.0003)	(0.0003)	(0.0006)	(0.0013)	
TNOM	0.4772*	0.4786*		0.4818*					0.2305*
	(0.033)	(0.0403)		(0.038)					(0.049)
PREDICT	1.043*	1.083*	0.462*	0.255**	0.046*	0.038*	0.0036	-3.915*	-1.561*
	(0.1455)	(0.1723)	(0.142)	(0.108)	(0.007)	(0.008)	(0.014)	(0.451)	(0.324)
N. Obs.	77	77	77	77	77	77	77	77	77
Adj. R2									
F-statistics	3.16	1.43	5.38	2.97	38.0	34.47	3.84	22.17	17.28

Dependent variable is RCA. Numbers in parentheses are standard errors.
The simbols (***), (**) and (*) indicate statistical significance at 10%, 5% and 1%, respectively.

$PREDICT_F$-I = E[*FORGN*|*c,Yel, CPROD, SIZE* , $\hat{\theta}$]}

$PREDICT_F$-II = E[*FORGN*|*c,YEL,CPROD, SCALBR, GSIZE* , $\hat{\theta}$]}

$PREDICT_F$-III = E[*FORGN*|*c,CPROD, SIZE, TAR* , $\hat{\theta}$]}

Except for model (ii), the *F-statistics* are all significant at 1.0%, and this statistics is quite lower than the original one-step *RCA* model for it has additional eighteen degrees of freedom in the numerator for the same degree in the denominator. The insignificance of (ii) has to due *inter allia* with the repetition of *CPROD,* even though in some specification such as (vii) it does not cause such a strong impact. It is worth noticing too that the coefficient of either *CPROD* or *CPCOST* shift to negative in some models, averting the case of *inverted market*, which can be explained by $PREDICT_F$ carrying additional information about industry's allocation. This result begs, however, for further examination. Finally, it is worth noticing that TAR and TNOM, as well as SIZE and the remaining variables for scale attained statistical significance, maintaining their signs. Variable *YEL* is though an exception: just in few cases it attained statistical significance, which is related to above commented problem of *CPROD*.

The last two models in Table 5 were estimated with the endogenous *FORGN* accounting for the exogenous impact of trade protection (i.e., *TAR*). In this case, *PREDICT* can be claimed to carry a control for the technology service β_6 in model (13) and, indeed, this is confirmed by the now negative sign of $PREDICT_F$, which remains statistically significant. That would mean that protection affects part of technology service form foreign affiliates, although it deserves further examinations, as the above commented change in the variables for marginal costs.

6. Conclusions

The production regime model showed that the location of foreign affiliates in Brazil was dictated by *market proximity* – local industry size and several indicator of returns to scale – rather than *factor proportions* dictated, reinforced by the irrelevance of comparative costs, during the import substitution industrialization period. The dominant horizontal integration of these MNFs was further reinforced by their negative correlation to the international sale expansion of these industries.

The singular impact of this production regime (*FORGN*) on country's relative export stems from both MNFs' technology services and the factor-content of their activity, given a set of industry's variables: marginal and fixed costs, together with markup pricing and a non-price competition term. The estimates showed that *FORGN* negatively impact on *RCA,* which is explained by foreign affiliates being concentrated in technology-intensive activities in a country scarcely endowed by skilled labor. This finding was corroborated by a descriptive analysis on the production regime against industries' factor content and corresponding *RCA*.

Lastly, to single out the technology-service impact from MNFs on exports we took the endogenously determined *FORGN*, containing the predicted location pattern of multinationals. The two-stage estimation showed that this endogenous variable, standing for MNFs as compared to same-industry domestic firms and thus for the former technology service, has a positive impact on *RCA*.

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Data Appendix.

RCA: UNCTAD, *Handbook of International Trade and Development Statistics, International Trade Statistics Yearbook*, and IBGE, *Anuário Estatístico do Brasil.* All in current US dollars.

***YEL*:** the same as *RCA* and also UN's *Commodity Trade Statistics Database.*

CPROD, CPCOST, GSCALE, ***GSIZE*** and ***SIZE***: UNIDO, *Industrial Statistics Database.* UN, *Yearbook of Industrial Statistics.* IBGE (idem). Valued-added deflated by the US and Brazil's GDP deflator, respectively.

TAR and ***TNOM***: Bergsman & Malan (1971); Neuhauss & Lobato (1978); Tyler (1983), and Kume (1989).

FORGN$_{it}$: Calabi *et al.* (1981), for 1967 and 1973, covering a total of 3,167 firms; Willmore (1987) for 1980, covering a total of 49,760 firms; and Bielschowsky (1994) for 1987-88, covering 3,310 firms. Their selection, among the several examined sampling, followed criteria of: (a) sample size, (b) compatibility of industry classification with the remaining variables; (c) classification of foreign firms, preferring the criteria of 25% or more of firm equity, and (d) proximity with the reference years (1967, 1973, 1980, 1987-88). Although Calabi *et al.* (idem) measure market share by capital value – the remaining ones are by the industry's sale – we chose it because: (i) alternative sampling for 1967 and 1973 do not present data on several industries, except Doellinger & Cavalcanti (1975), whose sample is too small (318 firms); (ii) there are no significant differences in the firms' market share by either capital or sales, indicating that firms' market share is determined by their by their capital size. Further information can be ordered from the author.