THE HECKSCHER-OHLIN THEOREM OF INTERNATIONAL TRADE THEORY: NEW EMPIRICAL TESTS FOR BRAZIL

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Abstract

Using Brazilian data, this paper empirically tests the Heckscher-Ohlin theorem. The results indicate that Brazil's exports taken as a whole are more labor-intensive than its import substitutes, as predicted. However, this is largely due to the great capital-intensity of oil, accounting for half of all imports. In fact, some indicators show Brazil's industrial exports as more capital-intensive than its non-oil imports, suggesting that not all Brazilian exports are labor intensive.

1. Introduction[1]

Of all the theories and theorems purporting to explain the pattern of international trade between countries, there is not doubt that the Heckscher-Ohlin (H-O) theorem has gained the greatest prominence. Empirical testing of the theorem has been prolific, and not untouched by controversy[2].
Leontief's ini- tial finding that U.S. exports were labor intensive, contrary to the predic- tions of the theorem, stimulated new theoretical refinements and empirical testing.

The relevance of the H-O theorem to less developed countries (LDCs) is great, given its important ramifications for the impact of trade strategies on employment and income distribution. The theorem states that, given competitive markets[3],
the pattern of trade between countries is determined by each nation's relative "endowments" of the factors of production. Since developed countries (DCs) are presumed to be relatively well-endowed with capital, while LDCs are characterized by abundant surplus labor, competitive markets dictate that labor will be relatively cheap in the LDCs and capital relatively expensive; the opposite should be true in the DCs. LDCs will hence have a "comparative advantage" over DCs in labor-intensive products, given their bountiful supply of low-wage labor. Since capital is scarce in the LDCs, the opportunity cost of producing capital-intensive goods that compete with imports from the capital-abundant DCs is great. Hence, the prediction of the H-O theorem is that a LDC's exports to the DCs will be labor intensive relative to its imports; that is, the capital/labor ratios associated with production of exports are lower than those for imports. This implies that "free trade" is a desirable trade strategy, in as much as employment creation for the surplus labor in LDCs is a policy goal. In terms of the current debate on trade strategies, advocates of the export production (EP) strategy invoke the H-O theorem to argue that openness to competitive international markets will naturally lead to LDCs producing and exporting these labor-absorbing goods to their wealthier, capital-abundant trading partners. Hence, efforts should be made to liberate trade, or at least to compensate for the bias in policy

against exports. According to the H-O theorem, an import substitution (IS) trade strategy (replacing capital-intensive imports with local production of the same goods) has a pejorative impact on employment and income distribution. Their production will create relatively few jobs, and generate a large amount of factor income for capital, which is by and large owned by upper income groups. Following this line of argumentation, a number of economists claim that the import-substituting industrialization pursued by many LDCs since the 1950s has exacerbated the severe income inequalities found in the Third World[4].

The purpose of this paper is to provide new empirical tests of the H-O theorem, with special application to Brazil. Brazil is of special interest as a LDC, as its industrialization has generally been successful[5].
The country has had experience with both import substitution (IS) in the 1950s and the export production (EP) strategy in the late 1960s and early 1970s. In fact, many former IS industries, such as automobiles and steel, are now important exporters. The composition of Brazil's exports has changed drastically in the past decade, as industrialized products now comprise roughly 60% of all exports; in 1970, the figure was just 26%. Given the capital-intensive nature of industrialized goods, it is not clear that Brazil's exports can still be characterized as "labor-intensive."

Previous empirical tests of the H-O theorem for Brazil almost exclusively use data for 1971 or earlier, before this major shift in the composition of exports took place. The studies by Tyler[6],
Rocca and Mendonca[7],
[8] all tested the H-O theorem by comparing the amount and Employmentandrelatedper unit increase in final demand for exports and import substitutes. These studies largely confirm the theorem, as Brazil's exports were found to create more employment per unit of output than its import substitutes. As pointed out by Barrantes, however, this is not an adequate test of the H-O theorem[9].
The H-O theorem involves two factors of production, labor and capital. A proper test involves a comparison of capital/labor ratios. In light of this, the ratio of value added accruing to capital divided by the wage bill was employed by Barrantes as a proxy for the capital/labor ratio. The heterogeneity of labor across sectors was also addressed, as an ad-justment for urban/rural wage differentials was made. Using 1970 data on the composition of imports and exports, his results once again confirmed the H-O theorem.

While Barrantes' method denotes a significant improvement, it is not without fault. Using the profit/wage ratio (value added to capital divided by the wage bill) as a proxy for the capital/labor ratio embodies the rather strong assumptions that capital is homogeneous across sectors, and receives the same rate of return in all sectors. These assumptions are quite unrealistic in the Brazilian context, as the productivity of capitaly[10]
and its rate of return vary significantly from sector to sector[11].
In view of this, the profit/wage ratio may not be a satisfactory proxy for the capital/labor ratio. Far preferable is an actual measure of the value of capital per worker, which is utilized in this study. The profit/wage bill will also be computed, in order to assess the reliability of this proxy for the capital/labor ratio.

The rest of this paper is structured in the following manner. First, the

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methodology and data employed in this study are described. Second, empirical results are given. Finally, conclusions and policy implications are given.

2. Description of the Model

2.1 Introduction

The purpose of the model is to quantitatively assess the capital/labor ratios associated with the production of exports and import substitutes. Non-traded goods are also added to the analysis for purposes of comparison. An open-ended, input-output technique is utilized, as this captures both the direct and indirect effects of increased final demand for a sector's output. In addition to the usual input-output framework, special treatment is given to the role of intermediate imports. Following Kim and Turrubiate[12], results are computed under various assumptions about the role of intermediate imports in meeting intermediate input demand.

2.2 Structure of the Model

The input-output system of Leontief begins with the equation stating that the domestic output of a sector (say lumber) equals the sum of final demand for the sector's output and intermediate input demand (e.g., lumber purchased by firms producing furniture), plus net exports. In matrix form, this can be expressed as

$$X = AX + F + E - M \qquad (1)$$

where X is a vector of domestic output, AX equals intermediate input demand, domestic final demand is F, exports are E, and imports equal M. Generalizing the model to the economy as a whole, each sector can be thought of as an element in the output vector, X. Vectors F, E, and M are of dimension jx1, where j equals the number of sectors in the economy. Matrix A is a square matrix of dimension ixj, where i=j. Each element (ij) in matrix A quantifies the amount of sector i's output needed as an input to produce a unit of j.

Imports are composed of both intermediate and final demand imports, with intermediate import demand dependent on the level of output:

$$M = Mf + AmX \qquad (2)$$

where Am is a square matrix of dimension ixj, with i=j, and Mf is a jx1 vector of final demand imports.

Domestic final demand can then be thought of as final demand (F) minus final demand for imports (Mf). Designating this domestic final demand as D, and combining equation (1) and (2) and solving for X, we have

$$X = (I - A + Am)^{-1} (D + E) \qquad (3)$$

In view of this framework, an exogenous increase in final demand can be viewed as coming from increased export demand (E) or an increase in domestic final demand (D). This increase in domestic final demand can be conceptualized as coming from an increase in demand for import substitutes (IS) or non-traded good (NT).

Quantifying the amount of factor income or value added (wages, profits, payments to the self-employed) generated by an exogenous increase in final demand requires the introduction of matrix Av, whose typical element (ij) shows the amount of direct factor income generated for factor i per unit of j produced. Pre-multiplying this matrix by the expression in (3), we obtain

$$V = Av(I - A + Am)^{-1} (D + E) \qquad (4)$$

where V is a vector of factor payments.

The capital/labor ratios associated with increased final demand can be measured by pre-multiplying the inverted matrix in (3) by vector K1, whose typical element (j) shows the capital/labor ratio associated with production in sector j:

$$Z = K1(I - A + Am)^{-1} (D + E) \qquad (5)$$

where Z is a vector of capital/labor ratios. To compare the capital/labor ratios associated with export production (EP), import substitution (IS), and production of non-traded goods (NT), the vector of final demand in equation (5) can be replaced, one at a time, with the appropriate trade composition vector. For each trade category, a column vector whose rows sum to unity is constructed, where each element in the vector represents the share of that sector in the category's output. Thus, if automobiles account for 10% of all exports, the value of the element representing the automobile sector is .1.

2.2   Treatment of Intermediate Imports

The amount of capital and labor required to produce the average basket of exports, import substitutes, and non-tradeables depends on the degree to which intermediate inputs are supplied by imports. The greater imports are, the smaller is the total employment of capital and labor through the "backward linkages" to domestic suppliers of intermediate inputs. If imported inputs meet almost all input demands, expansion of final demand will lead to relatively little employment for the capital and labor used by domestic input suppliers. On the other hand, if domestic producers supply all intermediate inputs, no factor employment will be "lost" through the leakage of imports. Since the total factor employment created under these different scenarios varies greatly, the capital/labor ratios associated with each situation are also likely to be different.

This indeterminacy in factor requirements under differing assumptions about intermediate inputs is dealt with by calculating upper an lower bounds for factor employment. In the lower-bound case, all intermediate inputs are supplied by imports. In the upper-bound scenario, all input needs are met domestically; this corresponds to the situation where there is total import substitution in intermediate goods.

The scenarios possible under alternative assumptions regarding intermediate imports are as follows:

$$\text{Case I: } Am=Am, \quad Z(I) = K1 (I - A + Am)^{-1} (D + E) \qquad (6)$$

Under Case 1, it is assumed that intermediate input demand is met by imports at

the same ratio as given in the input-output tables.

Case II: Am=A, Z(II) + K1 (D + E)   (7)

In this case, the only factor employment created is through direct requirements for capital and labor at the final stages of production. This is the lower-bound case for factor employment generation.

Case III: Am=0, Z(III) = K1(I - A)$^{-1}$ (D + E)   (8)

All intermediate inputs are supplied by domestic suppliers in Case III.

2.3 Data

The model used here requires three kinds of data: (1) input-output matrices; (2) data on factor income and capital intensity by sector; and (3) trade data. The 1975 input-output tables for Brazil, recently released by the Instituto Brasileiro de Geografia e Estatistica (IBGE), are used for matrices A and Am. Payments to capital, wage labor, and the self-employed are also given in the input-output tables. Data on wage payments to unskilled labor by sector were derived by taking the wage bill and multiplying it by the share of wages

This demonstrates that the low capital/labor ratios associated with export production are largely due to the backward linkages of exports to labor-intensive sectors, especially agriculture.

Alternative measure of the capital intensity of production under EP, IS, and NT are presented in Table 3[14]. The profit/wage bill ratio[15] indicates that exports are more labor intensive than import substitutes, but not in comparison with non-traded goods. When one considers the ratio of profits to wages paid to unskilled labor, however, exports are more labor intensive than non-tradeables. Thus, exports are more intensive in the most abundant factor of production in Brazil, unskilled labor.

Table 3

Capital Intensity of EP, IS, and NT

	EP	IS	NT
Profit/Wage Ratio	3.02	4.33	2.31
Profit/Unskilled Wage Ratio*	8.38	25.39	9.11
Profit/Labor Income**	2.13	3.70	1.83
Capital/Labor Ratio	99.23	229.38	104.40

*Defined as the ratio of profits to wage payments to those
  earning less than two times the minimum wage.
**Defined as profits divided by the sum of wages and payments
  to the self-employed.

Thus far, the capital intensity of EP, IS, and NT has been assessed with an analysis of the "average" basket of goods in each trade category. A less aggregated approach is now employed, so as to determine which sectors are most responsible for the relative capital intensity of each aggregate category. The

trade categories are disaggregated in the following way: Exports: agriculture and industry; Import Substitutes: oil and non-oil; Non-tradeables: agriculture, industry, and services. For each disaggregated group, a weighted average basket of final demand is formulated, as was done for the aggregate categories.

Various measures of the capital-intensity of EP, IS and NT by disaggregated category are presented in Tables 4-6. The labor-intensity of agriculture is most evident, as the capital/labor ratios of export and non-traded industry are 132% and 125% higher than their agricultural counterparts, respectively. The relatively heavy use of unskilled labor in agriculture is also noteworthy, especially export agriculture (Table 6). Another interesting facet of the disaggregated results is the capital-intensive nature of Brazil's industrial exports. These industrialized goods are not only more than twice as capital-intensive than non-traded industrial exports, but also 5% more capital intensive than non-traded industrial goods. Even as far as industrial goods are concerned, then, Brazil's industrial exports are not particularly labor intensive.

Table 4

Capital/Labor Income Ratios, Disaggregated Categories

Disaggregated Category	EP	IS	NT
Agriculture	63.61		62.41
Industry	147.27		140.23
Services			85.45
Oil		689.89	
Non-oil		127.48	

Table 5

Profit/Labor Income Ratios, Disaggregated Categories

Disaggregated Category	EP	IS	NT
Agriculture	1.86		1.70
Industry	2.33		1.90
Services			1.79
Oil		6.60	
Non-oil		2.22	

Table 6

Profit/Unskilled Wage Ratios, Disaggregated Categories

Disaggregated Category	EP	IS	NT
Agriculture	5.70		6.12
Industry	12.08		10.08
Services			11.00
Oil		60.57	
Non-oil		13.26	

The capital intensity of Brazil's import substitutes is in large part due to the extremely high capital/labor ratios associated with oil production (Table 4). Given that petroleum accounts for over 50% of all imports, this significantly raises the overall capital/labor ratio under IS. Brazil's non-oil import substitutes are not particularly capital-intensive; in fact, excepting the profit/unskilled labor ratio, the measures of capital-intensity used in Tables 4-6 show they are more labor intensive than Brazilian industrial exports.

Do these disaggregated results confirm or reject the H-O theorem? The theorem makes no particular prediction about the relative capital intensity of different sectors within the aggregate basket of goods considered to be exports or import substitutes. However, if we discount for the impact of oil, it is apparent that the greater labor-intensity of exports is solely due to the influence of labor-absorbing agricultural products in the export basket.

4. Conclusions and Policy Implications

It is clear that Brazil's import substitutes are more capital intensive than its exports. Under various assumptions about the role of intermediate imports and utilizing alternative measures of capital-intensity, exports are consistently more labor intensive than import substitutes. These results are in line with the predictions of the H-O theorem, which states that a relatively labor-abundant country like Brazil, trading primarily with developed countries, will export labor intensive goods and import capital intensive ones. While exports are more labor intensive than import substitutes, disaggregated analysis reveals that this is in large part due to the influence of oil in the import basket. Discounting for oil, some measure of capital-intensity actually depict Brazil's import substitutes as more labor-intensive than its industrial exports. Given the ever-increasing role of industrialized goods in the composition of exports, it is not inconceivable that Brazil's exports will soon be more capital intensive than its import substitutes. Future research will be necessary to clarify these issues.

ENDNOTES

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    See, for example, Wassily Leontief, "Domestic Production and Foreign Trade: The American Capital Position Re-examined," in R.E. Caves and H.G. Johnson, eds., Readings in International Economics (Illinois: Homewood, 1968); for more recent empirical work, see the collection of country studies in Anne Krueger, ed., Trade and Employment in Developing Countries (Chicago: University of Chicago Press, 1981).
3
    Some of the other assumptions that need to be made before the H-O theorem can be applied are: (1) tastes are the same in the trading countries; (2) countries share the same technology; and (3) there are no factor reversals.

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  See Werner Baer, "Import Substituting Industrialization in Latin America: Experiences and Interpretations," Latin American Research Review 12 (Spring 1972), 95-137.

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  See Werner Baer, The Brazilian Economy: Its Growth and Development (New York: Praeger, 1983).

6

  William G. Tyler, "O Comercio de Manufaturados e a Participacao do Trabalho Especializado: O Caso Basileiro," Estudos Economicos 2 (October 1972), 129-154.

7

  Carlos Rocca and Jose Mendonca de Barros, "Recursos Humanos e Estrutura do Comercio Exterior," Estudos Economicos 2 (October 1972), 89-110.

8

  Jose L. Carvaho and Claudio L.S. Haddad, Estrategios Comerciais e Absorcao de Mao de Obra No Brasil (Rio: Fundacao Getulio Vargas, 1980).

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  Alvaro H. Barrantes, "Testes Empiricos Do Theorema De Heckscher-Ohlin Para O Brasil: Resenha Da Literatura E Novos Resultados," mimeographed, 1984.

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  For example, see Jose A. Savasini and H. Kume, Custos dos Recursos Domesti cos da Exportacoes Brasileiras (Rio: Fundacao Dentro de Estudos de Comercio Exterior, 1979).

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  For a study examining the causes of these differing profit rates by sector, see Joseph Mooney, "A Quantitative Analysis of Market Structure and Performance in Brazil," (Unpublished Doctoral Dissertation, University of Notre Dame, 1982).

12

  Kwan S. Kim and Geraldo Turrubiate, "Structures of Foreign Trade and Income Distribution: The Case of Mexico," Journal of Development Economics 13 (1984), 263-278

13

  Andrea Calabi et al., Geracao de Poupancas e Estrutura de Capital no Brasil (Sao Paulo: Universidade de Sao Paulo, 1981).

14

  Given that our results do not vary significantly in the face of differing assumptions about the role of intermediate imports, all figures in Table 3 are computed under Case I.

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  All value added accruing to capital is referred to as "profit" in this context, although this is not strictly correct. Value added to capital includes rents and interest payments on debt.