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DISCUSSION PAPER

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LINKAGES AND ECONOMIC DEVELOPMENT: THE CASE OF BRAZIL RECONSIDERED

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ABSTRACT

This paper provides mathematically consistent calculations of the forward, backward, and total linkages in the Brazilian economy in 1975. Our results reveal, among other things, that: 1) high linkages cannot be exclusively associated with modern industrial sectors; 2) none of our linkage measures have any consistent relationship with domestic resource cost, our measure of efficiency; 3) there are some doubts on the proposition that Brazilian economic growth has been linkage-intensive; and 4) there are some important differences between "key" sectors from the standpoint of backward and forward linkages.

I - INTRODUCTION

The concept of linkages, first introduced by Hirschman (1958), has attracted a great deal of attention from development scholars. The principal concern in applied research utilizing the linkages concept has been the identification of "key" sectors. These key sectors are defined as those activities that display the greatest amount of linkage or interdependence with the activities of other sectors. This interdependence can take the form of either 1) "backward linkages", the dependence of a given sector on inputs produced by other sectors; or 2) "forward linkages", the role of a given sector in supplying inputs to other sectors. The basis of this concern with identifying key sectors is that these activities should receive special attention in planning and development schemes, as they have the greatest ability to stimulate the growth and development of sectors above and beyond themselves. This is especially important in the Brazilian context, where some scholars have attributed the success of Brazil's industrialization to the rapid growth of linkage-intensive sectors.[1]

Part of the appeal of Hirschman's linkages concept to development economists has been the fact that input-output tables, readily available for many less developed countries, provide the data necessary to compute the forward and backward linkages for various sectors of the economy. The apparent simplicity and ease of application of the linkages concept to input-output data, however, has largely proven illusory, for previous researchers have based their empirical estimates on mathematically inconsistent measures of backward, forward,and total linkages.

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[1]Werner Baer and I. Kerstenetsky, "Import Substitution and Industrialization in Brazil", American Economic Review 54 (May 1964): 411-25; cited in Ronaldo L. Locatelli, "Relações Intersetoriais e Estratégia de Desenvolvimento: O Caso Brasileiro Reexaminado", Revista Brasileira de Economia 37 (October/December 1983): 415.

Following the suggested method of Cella (1984), this paper presents mathematically consistent measures of linkages for the Brazilian economy. A ranking of each sector in terms of backward, forward, and total (backward plus forward) linkages is made, so as to indentify the key sectors of the Brazilian economy.[2] In addition, the relationship between sectoral performance on linkages and other indicators of sectoral performance (employment creation, domestic resource cost, wage income accruing to the poor, etc) is assessed. With this analysis, an assessment of the employment, efficiency, and distributive consequences of promoting the key sectors of the economy can be made. This paper also assesses whether or not the Brazilian development model has truly been linkage intensive, by 1) analyzing whether or not the most linkage-intensive sectors have experienced the greatest growth; and 2) assessing whether or not linkage-intensive sectors have received the greatest amount of subsidies and import protection.

This paper is organized in the following manner. First, the various attempts to measure linkages that have been employed in previous studies are presented and criticized. The method proposed by Cella (1984) is also delineated in this section. Second, the empirical results of the application of Cella's method to Brazilian data are given. Third, the relationship between sectoral performance on linkages and employment, income distribution, and efficiency is presented. Fourth, the linkage-intensity of the Brazilian model of economic development is critically examined. Finally, a summary section concludes the paper.

II - THE MEASUREMENT OF LINKAGES[3]

The first attempt to quantify the idea of intersectoral linkages was developed by Chenery and Watanabe (1958). Chenery

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[2]The exact definition of what constitutes a "key" sector has been fairly ambiguous in the literature. In the present context, it refers to a sector that scores high (relative to the economy-wide average) on the linkage indicator under discussion.

[3]This section is largely based on Cella (1984).

and Watanabe measured the backward linkages (BL) of sector j by quantifying the fraction of intermediate inputs in the value of final production in sector j. Forward linkages (FL) for sector j were calculated as the fraction of that sector's output that was destined for intermediate input use, as opposed to final demand. Of course, this measure of linkages gives a very incomplete picture, as indirect effects are not included in such a measure.

Yotopoulos and Nugent (1973) attempted to incorporate both direct and indirect effects in their concept of linkages, considering the sum of the n products necessary to produce a unit of final demand in industry j. This linkage measure was calculated as the column sum of sector j in the inverted input-output matrix. According to Jones (1976), however, the Yotopoulos and Nugent indicator of linkages is incomplete. Jones argued that while the inverted Leontief matrix contains both backward and forward linkages, the linkages of sector j extend beyond what is found in the column sum of sector j. Furthermore, the Yotopoulos and Nugent measure does not allow for a separation of backward and forward linkages.

Regarding the separation of backward and forward linkages, the proposal of Rasmussen (1958) is that the backward linkages of sector j can be measured by the value of intermediate goods needed to produce one unit of final demand for sector j, while forward linkages can be calculated by quantifying the amount of sector j needed to produce the total basket of final demand. The merit of this approach is that it includes both direct and indirect effects, and allows a separation of backward and forward linkages. The problem with the approach, nevertheless, is the serious inconsistency in the measure of FL. For while the proper measure of FL should incorporate the importance of sector j in producing all goods, this measure of FL only measures the impact of sector j in producing <u>sector j's</u> output.

Two recent attempts to resolve this problem with linkages are the "output approach" and the "hypothetical extraction approach". The former was first proposed by Augustinovics

(1970) and adopted by Jones (1976) and Bulmer-Thomas (1982). The use of this method supposedly corrects the problem with the Rasmussen technique. The output approach measure of BL is essentially the same as that of Rasmussen, that is, the column sum of the inverted Leontief matrix. The measure of forward linkages for sector j, however, is taken as sector j's row sum in the inverted matrix of allocation, D, where D_{ij} is the increase in the production of sector j necessary to support a unit increase in sector i. That is, $D_{ij} = q_j/Y_i$, where y_i is the value of production in industry i.

According to Cella (1984), a problem with this approach is that it does not allow one to measure total linkages (TL) by adding up the sum of BL and FL. In fact, since the coefficients of the inverted Leontief matrix are related to those in matrix D, adding up BL and FL to derive TL would overstate total linkages.

The method proposed by Cella (1984) to calculate linkages represents a distinct methodological improvement. As a starting point Cella follows Schultz (1977) in using the hypothetical extraction approach. More precisely, the technique involves assessing what sectoral production in the entire economy would be if sector j neither bought inputs from other sectors nor sold any of its output to other sectors. The difference between this hypothetical output and observed sectoral production indicates the total linkages of sector j. Thus, the total linkages (TL) of the n_1 productive sectors show in Table 1 can be represented by:

$$TL = i'(q - \bar{q}) \qquad (1)$$

where i' is a unitary vector and $\bar{q}$ is a vector of production derived from the hypothetical extraction method. In terms of Table 1, we have:

$$\bar{q}_1 = A_{11}\bar{q}_1 + f_1 = B_{11}f_1 \qquad (2)$$
$$\bar{q}_2 = A_{22}\bar{q}_2 + f_2 = B_{22}f_2$$

where A_{11} and A_{22} are the appropriate technical coefficient matrices and $B_{rr} = (I - A_{rr})^{-1}$, any r.

q_1 and q_2 are given by

$$\begin{aligned} q_1 &= A_{11}q_1 + A_{12}q_2 + f_1 \\ q_2 &= A_{21}q_1 + A_{22}q_2 + f_2 \end{aligned} \qquad (3)$$

Following Cella (1984), we can solve for q_1 and q_2 by

$$\begin{pmatrix} q_1 \\ q_2 \end{pmatrix} = \begin{pmatrix} H & HA_{12}\ B_{22} \\ B_{22}\ A_{21}\ H & B_{22}\ (I + A_{21}\ HA_{12}\ B_{22}) \end{pmatrix} \begin{pmatrix} f_1 \\ f_2 \end{pmatrix} \qquad (4)$$

where $H = (I - A_{11} - A_{12}\ B_{22}\ A_{21})^{-1}$

Combining the results from (2) and (4) we have:

$$\begin{pmatrix} q_1 - \bar{q}_1 \\ q_2 - \bar{q}_2 \end{pmatrix} = \begin{pmatrix} H - B_{11} & HA_{12}\ B_{22} \\ B_{22}\ A_{21}\ H & B_{22}\ A_{21}\ HA_{12}\ B_{22} \end{pmatrix} \begin{pmatrix} f_1 \\ f_2 \end{pmatrix} \qquad (5)$$

In light of equation (1), total linkages are thus

$$TL = [i'_a(H - B_{11}) + i'_b(B_{22}\ A_{21}\ H)]\ f_1 + [i'_a(HA_{12}\ B_{22}) + $$
$$+ i'_b\ (B_{22}\ A_{21}\ HA_{12}\ B_{22})]\ f_2 = BL + FL$$

where i'_a and i'_b are unitary vectors of the appropriate dimensions. Our backward linkage measure $[i'_a(H - B_{11}) + i'_b(B_{22}\ A_{21}\ H)]\ f_1$ quantifies the inputs needed to support sector 1's final demand, while our forward linkage measure $[i'_a(HA_{12}\ B_{22}) + i'_b(B_{22}\ A_{21}\ HA_{12}\ B_{22})]\ f_2$ is dependent on both 1) the amount of sector 1 that is used to support the final demand of sector 2, measured by $i'_a(HA_{12}\ B_{22})\ f_2$; and 2) the feedback of this output in sector 1 on sector 2, quantified by:

$i'_b(B_{22}A_{21}HA_{12}B_{22})\ f_2$.

TABLE 1

THE PARTITIONED SOCIAL ACCOUNTING MATRIX

	SECTOR 1 (m_1 industries)	SECTOR 2 (m_2 industries)	FINAL DEMAND	TOTAL SECTORAL OUTPUT
Sector 1 (m_1 industries)	$Z_{11}=A_{11}q_1$	$Z_{12}=A_{12}q_2$	f_1	q_1
Sector 2 (m_2 industries)	$Z_{21}=A_{21}q_1$	$Z_{22}=A_{22}q_2$	f_2	q_2
Value Added	Y'_1	Y'_2	0	X
Total Sectoral Output	q'_1	q'_2	X	-

Source: Adopted from Cella (1984).

As Cella (1984) demonstrates, the scalar $(i'_a H + i_b'B_{22} A_{21} H)\ f_1$ is the measure of backward linkages currently in vogue a la Jones (1976), where BL is taken to indicate the amount of direct and indirect inputs needed to sustain the output of sector 1.[4] Cella's measure of BL in equation 6 substracts from this measure the scalar $i'_a B_{11} f_1$. Given that this scalar measures transactions that are purely internal to sector 1, it is clear that these transactions should be excluded from any measures of linkages.

Given the assumption of nonsingularity of the matrices H, A_{11} and B_{22}, BL = 0 only when $A_{21} = 0$. That is, BL = 0 only in the case when sector 1 does not buy any inputs from sector 2. Similarly, FL = 0 only in the case when sector 1 does not sell any of its product as an input to sector 2.

[4]It should be noted that the Jones (1976) measure of BL arbitrarily assumes that f_1 is equal to unity. The problem with this assumption of a unitary final demand vector is discussed further in the text.

The Cella method differs from the hypothetical extraction method of Schultz (1977). In the terminology developed here, Schultz's method incorrectly supresses all of sector 1's activity. Designating the Schultz measure as TL*, we have

$$TL^* = TL - i'_a(H - B_{11})f_1 - i'_b(HA_{12}B_{22})f_2$$

The recent measure adopted by Meller and Marfan (1981) also differs from the Cella total linkages measure. In the terminology developed here, their measure is

$$TL^{**} = TL + i'_a B_{11} f_1$$

which overcorrects for the problems with Schultz's hypothetical extraction method.

A further problem with many previous attempts to measure linkages has been the arbitrary use of a unit final demand vector; that is, linkages were computed under the assumption that final demand for each sector of the economy was increased by one unit.[5] This is especially misleading when it comes to measuring forward linkages. By assuming a unit increase in final demand for each of the sectors, the forward linkages for sectors that supply relatively large sectors of the economy is seriously understated. For example, by assuming the same amount of final demand for both large sectors (e.g., automobiles) and small sectors (e.g., cosmetics) the forward linkages of sectors that are important suppliers to the automobile industry (such as metallurgy) will be understated. The estimates presented in this paper are based on the existing pattern of final demand, and give a much more realistic and useful guide to which sectors provide the greatest linkages.

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[5]See, for example, Jones (1976), Meller and Marfan (1981), and Locatelli (1985).

III - EMPIRICAL RESULTS

Empirical estimates of total linkages (TL), backward linkages (BL), and forward linkages (FL) for 29 sectors of the Brazilian economy are presented in Table 2.[6] The results highlight the central role of the metallurgy industry in the Brazilian economy, as this sector has the highest total and forward linkages. Of considerable surprise in Table 2, however, is the high total linkages of many non-manufacturing and "traditional" sectors, such as primary agriculture, food products, and transportation. The critical role of construction in stimulating other industries is also underscored in Table 2, as this sector has the highest value of backward linkages and the third highest amount of total linkages. The figures in Table 2 also reflect the fact that a high level of total linkages does not necessarily imply a high value for both forward and backward

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[6]Results were also computed for 121 sectors of the Brazilian economy, and are available upon request from the authors.

It should be noted that our linkage measure only incorporates domestic linkages; that is, the input-output coefficients do not include the imported inputs used to produce a sector's output. Similarly, the final demand vector does not incorporate final demand imports. In light of this, it is appropriate to note that our results are best suited for an ex-post analysis of linkages, that is, an analysis of which sectors have the greatest actual linkages (given the current level of dependence on imports). This is in contrast to an analysis of what potential linkages might be if all domestic inputs were supplied domestically. For relatively open economies, there can be a great difference in the linkage ranking of sectors, depending on whether imports are included or not (Bulmer-Thomas, 1978). In the Brazilian case, however, imports are such a small portion of total sectoral supply that differing assumptions about imports has little effect on our linkage measures. For example, there is a Spearman correlation coefficient of .93 between the the measures of actual and potential backward linkages for the 1970 Brazilian economy estimated by Locatelli (1985). Hence, the use of our results for ex-ante predictions of both 1) which sectors have the greatest linkages and 2) the impact of a linkage-intensive strategy on the variables is a valid exercise, given that there is a very small difference between actual and potential linkages.

TABLE 2

TOTAL, BACKWARD AND FORWARD LINKAGES BY SECTOR, 1975

(Million Cruzeiros)

SECTOR	BL	RANK	FL	RANK	TL	RANK
Agriculture	20 467	(09)	108 849	(03)	129 316	(05)
Mining	1 039	(23)	8 583	(18)	10 522	(20)
Nonmetallic Minerals	969	(28)	43 148	(09)	44 117	(12)
Metallurgy	9 220	(13)	169 200	(01)	178 420	(01)
Machinery	31 248	(05)	32 387	(10)	63 735	(10)
Electrical Equipment	12 532	(11)	25 982	(11)	38 515	(13)
Transportation Equipment	53 969	(03)	53 122	(07)	107 091	(06)
Lumber	1 115	(26)	24 142	(12)	25 257	(15)
Furniture	9 204	(14)	1 202	(24)	10 406	(21)
Paper	1 640	(24)	20 678	(14)	22 319	(17)
Rubber	1 986	(22)	22 012	(13)	23 998	(16)
Leather	458	(29)	3 403	(21)	3 861	(27)
Chemicals	53 435	(10)	120 528	(02)	141 260	(04)
Pharmaceuticals	2 521	(21)	3 358	(22)	5 879	(26)
Cosmetics	5 855	(15)	836	(25)	6 691	(25)
Plastic	1 054	(27)	17 642	(15)	18 695	(18)
Textiles	22 940	(08)	57 009	(06)	79 948	(08)
Clothing	26 134	(07)	817	(26)	26 951	(14)
Food Products	114 596	(02)	51 781	(08)	166 377	(02)
Beverages	4 570	(15)	3 428	(20)	7 997	(22)
Tobacco	3 737	(18)	13	(28)	3 750	(28)
Printing & Publishing	3 509	(19)	3 942	(19)	7 451	(23)
Construction	157 254	(01)	0	(29)	157 254	(03)
Miscellaneous Industrial Products	4 229	(17)	3 169	(23)	7 397	(24)
Electricity and Sanitation	2 795	(20)	11 488	(17)	14 823	(19)
Commerce & Distribution	10 909	(12)	66 204	(04)	77 114	(09)
Transportation	48 197	(04)	57 468	(05)	106 664	(07)
Communications	1 156	(25)	286	(27)	1 411	(29)
Other Services	32 694	(06)	14 552	(16)	45 653	(11)
Average*	31 768		55 829		70 387	

*NOTE: Value-added weights were assigned to each sector in computing the averages.

linkages; for example, all of construction's linkages are of the backward variety. Hence, while a high value for either BL or FL implies a high level of total linkages, BL and FL are not positively related; in fact, sectors that tend to rank high in terms of backward linkages tend to be those sectors with the lowest amount of forward linkages (Table 3).

TABLE 3

CORRELATIONS BETWEEN LINKAGE MEASURES

	BL	FL	TL	BLVP	FLVP	TLVP
BL	1.000					
FL	-.249*	1.000				
TL	.371*	.669*	1.000			
BLVP	.857*	-.551*	.014	1.000		
FLVP	-.640*	.773*	.266	-.677*	1.000	
TLVP	-.180*	.488*	.437*	-.120	.717*	1.000

*Significant at the .05 confidence level.

Legend: BL=backward linkages; FL=forward linkages; TL=total linkages; BLVP=backward linkages per unit of sectoral production; FLVP=forward linkages per unit of sectoral production; TLVP=total linkages per unit of sectoral production.

NOTE: Figures represent Spearman correlation coefficients.

The ranking of sectors by BL reveals the important role of the chemicals and transportation equipment sectors as source of demand for other sectors output. What is most noteworthy with respect to the ranking of sectors according to backward linkages, however, is the high linkages of both the food products sector and certain service sector activities, such as transportation. Thus, while the concept of linkages has often been used as a justification for the promotion of modern industrial sectors, our calculations reveal that these activities are not necessarily those with the greatest backward linkages. Regarding forward linkages, it is clear that modern industrial sectors such as metallurgy, transportation equipment, and chemicals play critical roles as input suppliers in the Brazilian economy. Nevertheless,

the forward linkages of nonindustrial sectors such as agriculture and commerce and distribution are also quite large. Hence, our results suggest that high backward and forward linkages are not the exclusive domain of modern manufacturing activities. This conclusion is not without policy relevance, for it implies that efforts to improve efficiency and productivity (which can be transferred throughout the economy via forward linkages to other sectors) should not be exclusively centered on modern industrial activities.

The figures in Table 2 do not provide a reliable guide to which sectors provide the greatest linkages per unit of output, since the linkage measures do not take into account the differing size of the sectors. In order to provide a measure of linkages per unit produced, the total, backward, and forward linkages in Table 2 were divided by the value of sectoral production.[7]

The normalized ranking of linkages in Table 4 reiterates the ability of certain light industries, such as clothing and food products, to generate a high amount of backward linkages per unit produced. Among modern industrial sectors, the transportation equipment industry generates the greatest amount of backward linkages per unit produced. The aggregation of automobile production with other parts of the transportation equipment industry (production of vehicle parts and so on) masks the great ability of the automobile industry to stimulate supplying industries. The automobile industry generates 1.67 backward

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[7]The rationale for this normalization is as follows. For each sector j, the final demand vector for the entire economy should be scaled down appropriately in order to have that final demand level which requires one unit of production in sector j. Assume that the sector under consideration is sector 1. In this case, to find the level of final demand requiring one unit of production in sector 1, we have $1 = A^1F(t1)$, where A^1 is the first row of matrix $(I - A)^{-1}$, F is the final demand vector for the entire economy, and t1 is our unknown scalar. Given that A^1F equals the output in sector 1, q1, then t1 must equal 1/q1. We are indebted to Guido Cella for this suggested method of normalization.

linkages per unit produced, far more than any sector presented in Table 4.

The forward linkage rankings reveal that rubber and metallurgy generate the greatest amount of forward linkages per unit produced. Also scoring high on this criterion are some traditional industrial activities such as lumber, nonmetallic mineral products, and paper. Thus, while these sectors may not generate the greatest absolute amount of forward linkages, they still would play a critical role in a development strategy designed to encourage these sectors that are linkage-intensive.

The ranking of sectors according to total linkages per unit of output is headed by industrial activities such as rubber, metallurgy, and transportation equipment. The support of the Brazilian state for these industrial activities may lead one to infer that Brazilian policymakers have consciously followed a linkage-intensive development strategy. This proposition in carefully examined in section IV, where the relationship between linkages and economic policy is assessed.

IV - LINKAGES AND OTHER CRITERIA OF SECTORAL PERFORMANCE

Spearman correlation coefficientes between linkages measures and other variables assessing sectoral performance are presented in Table 5.[8] Regarding the non-normalized linkage measures, the figures indicate a weak relationship between labor intensity and backward linkages. This does not imply that high BL sectors have favorable employment or distributive consequences, however, as no significant correlations emerge between BL, GINI, or EMPLOY. As one wold expect, Table 5 reflects the fact the larger sectors will tend to have higher linkages, as BL, FL, and TL are all significantly correlated with VALPROD.

[8] All 121 sectors of the Brazilian economy were used for the correlation analysis results that are presented in Table 5. The domestic resource cost data covered 102 tradeable sectors (agriculture and manufacturing) for 1980.

TABLE 4

NORMALIZED RANKING OF LINKAGE MEASURES

SECTOR	BLVP	RANK	FLPV	RANK	TLVP	RANK
Agriculture	.132	(19)	.704	(13)	.836	(19)
Mining	.187	(17)	.828	(10)	1.015	(15)
Nonmetallic Minerals	.031	(29)	1.367	(04)	1.397	(07)
Metallurgy	.090	(25)	1.644	(02)	1.733	(02)
Machinery	.503	(08)	.521	(15)	1.025	(13)
Electrical Equipment	.318	(13)	.660	(14)	.979	(16)
Transportation Equipment	.775	(03)	.763	(12)	1.539	(03)
Lumber	.065	(27)	1.397	(03)	1.461	(04)
Furniture	.756	(04)	.099	(25)	.855	(17)
Paper	.091	(24)	1.148	(06)	1.239	(10)
Rubber	.153	(18)	1.700	(01)	1.853	(01)
Leather	.121	(20)	.900	(09)	1.022	(14)
Chemicals	.443	(21)	.998	(07)	1.170	(11)
Pharmaceuticals	.212	(15)	.282	(21)	.493	(24)
Cosmetics	.740	(05)	.106	(24)	.846	(18)
Plastic	.073	(26)	1.227	(05)	1.300	(08)
Textiles	.411	(11)	1.021	(08)	1.431	(05)
Clothing	1.082	(01)	.034	(26)	1.116	(12)
Food Products	.876	(02)	.396	(17)	1.272	(09)
Beverages	.450	(09)	.338	(19)	.787	(20)
Tobacco	.587	(07)	.002	(28)	.589	(22)
Printing & Publishing	.197	(16)	.222	(22)	.419	(27)
Construction	.337	(12)	.000	(29)	.337	(28)
Miscellaneous Industrial Products	.434	(10)	.325	(20)	.758	(21)
Electricity and Sanitation	.106	(22)	.434	(16)	.540	(23)
Commerce & Distribution	.064	(28)	.391	(18)	.456	(25)
Transportation	.632	(06)	.753	(11)	1.398	(06)
Communications	.099	(23)	.024	(27)	.124	(29)
Other Services	.304	(14)	.135	(23)	.424	(26)
Average*	.271		.520		1.154	

*Note: Value-added weights were assigned to each sector in computing the averages.

TABLE 5

CORRELATIONS AMONG LINKAGE AND SECTORAL PERFORMANCE INDICATORS

	BL	FL	TL	BLVP	FLVP	TLVP
EMPLOY	.093	.036	.054	.205*	.179*	.067
GINI	-.088	-.130	-.146	-.131	.116	.039
WPOOR	.033	-.004	.024	.240*	-.140	.020
K/L	-.151**	.080	-.076	.180*	.067	-.064
VALPROD	.609*	.458*	.759*	-.007	-.192*	-.247*
IMPORT	-.052	.132	.035	-.159**	.263*	.207*
DRC80	.076	-.089	-.044	.107	-.050	.036

Note: Figures indicate Spearman correlation coefficients
* = significant at the .05 confidence level.

Legend: EMPLOY=total employment (in man-years) generated per million cruzeiro increase in final demand;

GINI=Gini coefficient of income distribution; indicates distribution of the marginal income resulting from a unit increase in final demand for sectoral output;

WPOOR=share of wage income accruing to the poor per unit increase in sectoral final demand;

K/L=capital income/labor income ratio (from income derived from a unit increase in sectoral final demand);

VALPROD=value of production in sector;

IMPORT=intermediate imports required per unit increase in final demand;

DRC80=domestic resource cost for 1980.

The methodology used to derive all the variables except DRC80 can be found in Benedict J. Clements, Foreign Trade, Employment, and Income Distribution in Brazil (New York: Praeger, 1988). DRC80 data is taken from Juan Hersztajn-Moldau and Roberto Eli Pelin, "O Custo dos Recursos Domésticos das Exportações Brasileiras em 1980", Pesquisa e Planejamento Econômico 16 (April 1986):189-222.

Turning to our normalized linkage measures, the results indicate that a development strategy that gives a high priority to those sectors with high backward linkages per unit of output will have a favorable impact on employment. A high level of BLVP is also associated with a relatively low level of intermediate import use, given the negative relationship between BLVP and IMPORT. These results are not surprising, given that many of the sectors with high backward linkages per unit of output are traditional, labor intensive activities (Table 4). High forward linkages per unit of output, however, are associated with low employment creation and relatively heavy reliance on imported inputs. Likewise, high total linkages per unit of output are positively correlated with import use. There are no negative employment or distributive repercussions in promoting sectors characterized by high TLVP, however, as no significant correlation emerges between TLVP, EMPLOY, or GINI. It should also be noted that a sector's ability to generate linkages (per unit of output) does not increase with sector size; in fact, both forward and total linkages per unit output are negatively correlated with the value of sectoral production.

None of the linkage measures shows any systematic relationship with our efficiency measure, domestic resource cost (DRC). Domestic resource cost measures, at shadow prices, the total cost of domestic resources needed to generate a dollar of foreign exchange. The lower a sector's DRC, the greater the amount of foreign exchange that can be earned with a given amount of resources. Given the absence of any significant relationship between a sector's DRC and its ability to create linkages with other economic activities, our results do not indicate that a linkage-intensive development strategy will improve aggregate economic efficiency.

V - LINKAGES AND ECONOMIC POLICY

Has the Brazilian model of development given special emphasis to linkage-intensive sectors? To examine this proposition, correlations between variables that assess sectoral priorities of policymakers and linkage measures were calculated. Examining the

historical record, it does not appear that linkage intensive sectors have experienced the greatest growth, as Table 6 shows no significant correlations between our linkage measures and sectoral growth rates for any of the historical time periods examined. Furthermore, the structure of protection does not benefit high linkage sectors; in fact, sectors with high total linkages per unit of output tend to receive the least protection from imports. This can be seen in Table 7 from the statistically significant correlations between total linkages per unit of output (TLVP) and two measures of protection, net effective protection (NET) and the nominal tariff rate (NOM). High linkage sectors do not receive special attention in Brazil's export promotion program; there is no statistically significant relationship between net effective

TABLE 6

LINKAGES AND GROWTH RATES FOR MANUFACTURING SECTORS (SPEARMAN RANK CORRELATION COEFFICIENTS)

	BL	FL	TL	BLVP	FLVP	TLVP
G1949-61	.165	.218	.254	.206	.006	.178
G1962-74	-.078	-.077	-.099	-.081	-.022	-.035
G1968-74	-.192	-.024	-.113	-.045	.160	.192

Note: Number of observations=21. Growth rates are measured as the growth of sectoral value added, as reported in Ronald L. Locatelli, Industrialização, Crescimento e Emprego: Uma Avaliação da Experiência Brasileira (Rio de Janeiro: IPEA/INPES, 1985):219.

export promotion (NETEXP) and our linkage measures. The only way in which state policy has contributed to a linkage-intensive strategy is through the operation of state enterprises. State enterprises tend to be found in sectors with high levels of forward linkages and forward linkages per unit of output, such as metallurgy and chemicals. The lack of a statistically significant relationship between our linkage per-unit output measures and the states share of investiment is a bit misleading, as state enterprises are concentrated in a few select sectors. Hence, while state enterprise is not always found in high linkage sectors, one can

still characterize state enterprise as being concentrated in those sectors with relatively high forward linkages.

TABLE 7

SPEARMAN RANK CORRELATIONS AMONG LINKAGE MEASURES AND INDICATORS OF SECTORAL PROTECTION AND PROMOTION

	BL	FL	TL	BLVP	FLVP	TLVP
NOM	.096	.235	-.093	.223	-.175	.039
NET	.346	-.208	-.106	.333	-.450*	-.370**
EXPROMO	.170	-.085	.066	.199	-.041	.241
STATEINV	.066	.340**	.186	-.197	.130	.001
STATESHR	-.064	.270	.033	-.249	.077	-.102
MNCINV	.307	.399*	.456*	.078	.269	.407*
MNCSHR	-.065	.047	-.0 81	.158	.208	.341**

Note: number of observations=29. See Appendix for further description of the variables.

*significant at the .05 confidence level.

**significant at the .10 confidence level.

Legend: NOM = nominal tariff, 1980-91;
NET = net effective protection, 1981;
EXPROMO = net effective export promotion;
STATEINV = value of state enterprise production in that sector;
STATESHR = share of state enterprises in total sectoral production
MNCINV = value of multinational corporation production in that sector;
MNCSHR = share of multinational corporations in total sectoral production.

Also of interest in Table 7 is the fact that MNC corporations have chosen to locate in linkage-intensive sectors of the economy. MNC operations tend to be found in sectors with high forward and total linkages, as witnessed by the significant correlation between MNCINV, FL and TL. Furthermore, the multinational share of sectoral sales (MNCSHR) tends to be highest in those sectors with a high level of total linkages per unit of out-

put (TLVP). Hence, the relative openness of Brazil to foreign investment is not at odds with a linkage-intensive development strategy, although the general tenor of sectoral policy has not been favorable to linkage-intensive growth.

VI - SUMMARY

This paper has provided mathematically consistent calculations of the forward, backward, and total linkages in the Brazilian economy in 1975. Previous applications of the linkages concept to less developed countries, including Brazil, have used measures that either do not allow a disaggreation of total linkages into a forward and backward component, or are based on mathematically inconsistent disaggregation. The arbitrary use of a unit final demand vector in these empirical applications has also compromised the usefulness of these quantitative estimates.

Our results for the Brazilian economy reveal that high linkages cannot be exclusively associated with modern industrial sectors. This is especially true with respect to backward linkages, as many sectors with a high level of BL and FL per unit of output are found outside of heavy industry. These results are consistent with those of Locatelli for 1970, who, using the Jones (1976) method of computing linkages, found that consumer nondurable goods sectors are among the "key" sectors of the Brazilian economy.[9] Our calculations also reveal, however, that there are some important differences between key sectors from the standpoint of backward and forward linkages. Sectors that generate a relatively high level of BL per unit of output tend to perform more favorably on criteria such as reliance on domestic suppliers (low import dependence) and employment generation. Activities with high FL per unit of output, on the other hand, tend to perform poorly on these grounds; similarly, high total linkages per unit of output are associated with a reliance on imported inputs. None of our

[9] Ronaldo L. Locatelli, Industrialização, Crescimento e Emprego: Uma Avaliação da Experiência Brasileira (Rio de Janeiro: IPEA/INPES, 1985):115.

linkage measures have any consistent relationship with domestic resource cost, our measure of efficiency. Hence, while a development strategy that promotes key sectors from a backward linkage standpoint may have a favorable impact on employment generation, there is no reason to suppose that this will lead to a more efficient allocation of resources.

Our results cast doubt on the proposition that Brazilian economic growth has been linkage-intensive. In fact, many aspects of economic policy, such as trade policy, tend to retard the growth of linkage-intensive sectors. State investiment tends to be located in sectors with high total linkages, such as metallurgy and chemicals; nevertheless, the state is absent in other high linkage activities. Hence, while Brazilian economic policy has helped foment a vertically-integrated industrial economy, the success of this endevour cannot be attributed to conscious government effort to promote linkage-intensive economic activities.

APPENDIX

Variables used in Table 7

NOM: Nominal legal tariff in 1980, as reported in William G. Tyler, "Effective Incentives for Domestic Market Sales and Exports," Journal of Development Economics 18 (1985): 219-42;

NET: Net effective protection, as calculated in Tyler, "Effective Incentives";

EXPROMO: Net effective export promotion, as calculated in Tyler, "Effective Incentives";

STATESHR: share of state enterprises in sectoral sales. The shares for each manufacturing sector were calculated with 1980 data from Larry Willmore, "Controle Estrangeiro e Concentração na Indústria Brasileira", Pesquisa e Planejamento Econômico 17 (April 1987), excepting metallurgy. Given the incompatibility of some data sources with our 29 sector aggregation, other data sources were used for the remaining sectors. For metallurgy, 1972 data from Carlos von Doellinger and Leonardo C. Cavalcanti, Empresas Multinacionais na Indústria Brasileira (Rio de Janeiro: IPEA/INPES, 1979) were used; for mining, 1980 data from Werner Baer, The Brazilian Economy: Growth and Development (New York: Praeger Publishers, 1983) were utilized; for agriculture, construction, electricity and sanitation, commerce and distribution, transportation, communication, and other services, 1975 data from Andrea Calabi, Gerald Reiss, and Paulo Levy, Geração de Poupanças e Estrutura de Capital das Empresas no Brasil (São Paulo: Instituto de Pesquisas Econômicas, 1981) were employed.

STATEINV: state enterprise output, 1975; calculated by multiplying 1975 sectoral production by the state enterprise share of sales.

MNCSHR: multinational corporation share of sectoral sales, as given by the same data sources used for STATESHR;

MNCINV: multinational corporation output, 1975, calculated by multiplying 1975 sectoral production by the multinational corporation share of sales.

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