An Overview of the Productive Structure of the Amazon Region: Using the Eyes of an Interregional Input-Output System

Guilhoto, Joaquim José Martins and Sesso Filho, Umberto Antonio

University of São Paulo, State University of Londrina

2005

An Overview of the Productive Structure of the Amazon Region: Using the Eyes of an Interregional Input-Output System[1]

Joaquim José Martins Guilhoto

University of São Paulo, São Paulo, Brazil

Regional Economics Applications Laboratory (REAL) at
The University of Illinois at Urbana-Champaign, USA

CNPq Scholar

e-mail: guilhoto@usp.br

Umberto Antonio Sesso Filho

State University of Londrina, Paraná, Brasil

e-mail: umasesso@uel.br

ABSTRACT

There is a scarcity of economic studies about the economy of the Amazon region, and specially about its productive structure. The goal of the present study is to shed some light on the way that the productive relations take place among the states of the Amazon region and between them and the rest of Brazil. This study takes as the main source of data an interregional input-output system consisted of 10 regions (nine Amazon states and the Rest of Brazil region) constructed for the year of 1999 by Guilhoto et al. (2002) for the Amazon Bank (BASA). The analysis is conducted by first studying, through the interregional input-output system, how the economic relations take place in the Amazon region. Then, through a series of methodologies, like multipliers, and backward and forward linkages, and using the concept of Electroeconogram it is made a comparative study of the differences in productive structures among the Amazon Region states.

Key Words: Amazon Region, Productive Structure, Input-Output.

JEL Classification: R15

[1] The first author would like to thank FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo) for the financial support that made possible to attend and to present a previous version of this paper at the 43rd Congress fo the European Regional Science Association in Jyväskylä, Finland.

1. INTRODUCTION

There is a scarcity of economic studies about the economy of the Amazon region, and specially about its productive structure. The goal of the present study is to shed some light on the way that the productive relations take place among the states of the Amazon region and between them and the rest of Brazil.

This study takes as the main source of data an interregional input-output system consisted of 10 regions (nine Amazon states and the Rest of Brazil region) constructed for the year of 1999 by Guilhoto et al. (2002) for the Amazon Bank (BASA).

The analysis in this paper is conducted by first studying, through the interregional input-output system, how the economic relations take place in the Amazon region. Then, through a series of methodologies, like multipliers, and backward and forward linkages, and using the concept of Electroeconogram it is made a comparative study of the differences in productive structures among the Amazon Region states.

In the next section it is presented a brief overview of the Amazon region, the third section will present the methodology used in the analysis. The results are presented in the fourth section and the final comments in the last section.

2. A BRIEF OVERVIEW OF THE AMAZON REGION

The main indicators of the Amazon region are presented in Table 1, while Figure 1 gives an idea of localization and size of the this region in Brazil. The Amazon region consists of nine (Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, Tocantins, Maranhão, and Mato Grosso) out of the 27 Brazilian States (Brazil is a Federative Republic with 26 states and 1 Federal District). In general, this region is characterized by having a great share of the Brazilian territory, however, with a small population, and a low density of population per Km^2. The Amazon region has a share of 6.5% of the Brazilian GDP, and the values for the per capita income are below the national average.

Following Guilhoto et al (2002) the service sector is the most important one for the Amazon region, with a share of 61.2% of its GDP, against a share of 59.7% for Brazil as a whole. For the agricultural and industrial sectors the shares are respectively, 16.0% and 22.8% for the Amazon Region, and 8.0% and 32.3% for the Brazilian Economy.

Table 1. Main Indicators of the Amazon Region for 1999

Region	GDP *(US$ Million)*	Population *(Thousand)*	Per Capita GDP *(US$)*	Area *(Thousand Km²)*	Density *(Pop / Km²)*
Acre	849	547	1,552	153	3.59
Amapá	864	462	1,869	143	3.24
Amazonas	8,485	2,761	3,073	1,571	1.76
Pará	9,090	6,098	1,491	1,248	4.89
Rondônia	2,740	1,360	2,015	238	5.72
Roraima	446	316	1,409	224	1.41
Tocantins	1,149	1,138	1,009	277	4.11
Maranhão	4,318	5,590	772	332	16.84
Mato Grosso	6,383	2,467	2,587	903	2.73
Amazon Region	**34,323**	**20,740**	**1,655**	**5,088**	**4.08**
Rest of Brazil	496,811	147,170	3,376	3,426	42.96
Brazil	**531,134**	**167,910**	**3,163**	**8,514**	**19.72**

Source: IBGE (2002a), IBGE (2002b)

Figure 1: Map of the Brazilian States and the Amazon Region

3. THEORETICAL BACKGROUND

The intersectoral flows in a given economy can be represented by the following system

$$X = AX + Y \tag{1}$$

where X is a (nx1) vector with the value of the total production in each sector, Y is a (nx1) vector with values for the final demand, and A is a (nxn) matrix with the technical coefficients of production (Leontief, 1951). In this model, the final demand vector can be treated as exogenous to the system, such that the level of total production can be determined by the final demand, i.e.,

$$X = BY \tag{2}$$

$$B = (I - A)^{-1} \tag{3}$$

where B is a (nxn) matrix of the Leontief inverse.

3.1. Multipliers

From the multipliers results it is possible to measure the direct and indirect effects of a change in the final demand over production, income, employment, etc. (see Miller and Blair, 1985).

From the Leontief inverse matrix (B) defined above one has that the production multiplier of type I for each economic sector is given by:

$$P_j = \sum_{i=1}^{n} b_{ij} \qquad j = 1,\ldots,n \tag{4}$$

where P_j is the production multiplier for sector j and b_{ij} is an element of matrix B.

3.2. The Rasmussen/Hirschman Approach

The work of Rasmussen (1956) and Hirschman (1958) led to the development of indices of linkage that have now become part of the generally accepted procedures for identifying key sectors in the economy. Define b_{ij} as a typical element of the Leontief inverse matrix, B; B^* as the average value of all elements of B, and if $B_{\bullet j}$ and $B_{i\bullet}$ are the associated typical column and row sums, then the indices may be developed as follows:

Backward linkage index (power of dispersion):

$$U_j = \left[B_{\bullet j} / n \right] / B^* \tag{5}$$

Forward linkage index (sensitivity of dispersion):

$$U_i = \left[B_{i\bullet} / \bar{n} \right] / B^* \tag{6}$$

One of the criticisms of the above indices is that they do not take into consideration the different *levels* of production in each sector of the economy, what it is done by the pure linkage approach presented in the next section.

3.3. The Pure Linkage Approach

As presented by Guilhoto, Sonis and Hewings (1996) the pure linkage approach can be used to measure the importance of the sectors in terms of production generation in the economy.

Consider a two-region input-output system represented by the following block matrix, A, of direct inputs:

$$A = \left(\begin{array}{c|c} A_{jj} & A_{jr} \\ \hline A_{rj} & A_{rr} \end{array} \right) \tag{7}$$

where A_{jj} and A_{rr} are the quadrate matrices of direct inputs within the first and second region and A_{jr} and A_{rj} are the rectangular matrices showing the direct inputs purchased by the second region and vice versa.

From (7), one can generate the following expression:

$$B = (I - A)^{-1} = \begin{pmatrix} B_{jj} & B_{jr} \\ B_{rj} & B_{rr} \end{pmatrix} = \begin{pmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{pmatrix} \begin{pmatrix} \Delta_j & 0 \\ 0 & \Delta_r \end{pmatrix} \begin{pmatrix} I & A_{jr}\Delta_r \\ A_{rj}\Delta_j & I \end{pmatrix} \tag{8}$$

where:

$$\Delta_j = \left[I - A_{jj} \right]^{-1} \tag{9}$$

$$\Delta_r = \left[I - A_{rr} \right]^{-1} \tag{10}$$

$$\Delta_{jj} = \left[I - \Delta_j A_{jr} \Delta_r A_{rj} \right]^{-1} \tag{11}$$

$$\Delta_{rr} = \left(I - \Delta_r A_{rj} \Delta_j A_{jr}\right)^{-1} \tag{12}$$

By utilizing this decomposition (equation 8), it is possible to reveal the process of production in an economy as well as derive a set of multipliers/linkages.

From the Leontief formulation:

$$X = \ I - A\ ^{-1} Y \tag{13}$$

and using the information contained in equations (8) through (12), one can derive a set of indexes that can be used: a) to rank the regions in terms of its importance in the economy; b) to see how the production process occurs in the economy.

From equations (8) and (13) one obtains:

$$\begin{pmatrix} X_j \\ X_r \end{pmatrix} = \begin{pmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{pmatrix} \begin{pmatrix} \Delta_j & 0 \\ 0 & \Delta_r \end{pmatrix} \begin{pmatrix} I & A_{jr}\Delta_r \\ A_{rj}\Delta_j & I \end{pmatrix} \begin{pmatrix} Y_j \\ Y_r \end{pmatrix} \tag{14}$$

which leads to the definitions for the Pure Backward Linkage (PBL) and for the Pure Forward Linkage (PFL), i.e.,

$$\begin{aligned} PBL &= \Delta_r A_{rj} \Delta_j Y_j \\ PFL &= \Delta_j A_{jr} \Delta_r Y_r \end{aligned} \tag{15}$$

where the PBL will give the pure impact on the rest of the economy of the value of the total production in region j, $\left(\Delta_j Y_j\right)$: i.e., the impact that is free from a) the demand inputs that region j makes from region j , and b) the feedbacks from the rest of the economy to region j and vice-versa. The PFL will give the pure impact on region j of the total production in the rest of the economy $\left(\Delta_r Y_r\right)$.

As the PBL and PFL are show in current values, the pure total linkage (PTL) can be obtained by adding the two previous indices, i.e.,

$$PTL = PBL + PFL \tag{16}$$

The pure linkage indices can also be normalized by the average value of the sectors in the economy such that the normalized indices show how many times a sector is bigger or smaller than the average sector in the economy. In such a way it is possible to use these indices to a direct comparison of the productive structure of economies with different sizes and currencies. In the same way they do allow for a time comparison in

economies with inflation or that have changed their currency.

4. THE PRODUCTIVE STRUCTURE OF THE AMAZON REGION

This section presents the main results obtained by applying the above methodology in the interregional input-output model constructed by Guilhoto et al (2002) for 91 industries (sectors) and 141 commodities for 10 regions (Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, Tocantins, Maranhão, Mato Grosso, and Rest of Brasil) for the year o 1999.

First it is presented and analysis of how the flow of goods and services take place among the region, then it is made a comparative study of the productive structure of the states of the Amazon region.

4.1. Flow of Goods and Services

Table 2 shows how the shares of total imports (intermediate and final consumption) made by one region are distributed among the source regions. It is possible to see the great dependence on the imports from the Rest of Brazil region, over 85%, showing a small level of trade among the states of the Amazon region. This can be explained, in part, by the low level of industrialization found in the region as well as by transportation problems. The Rest of Brazil region buys products mainly from the states of Amazonas, Mato Grosso and Pará. The electronic goods produced in the Free Zone of Manaus can explain the great share of the Amazonas state, given that the industries producing in the Free Zone of Manaus can import the electronic components, used in production, free of duties.

The low flow and dependence among the Amazon region is confirmed by looking at Figures 2 to 4 that show the landscapes of the Leontief inverse for the interregional system, first considering the whole system (Figure 2), them removing the columns and rows corresponding to the Rest of Brazil region (Figure 3), and finally removing the values for the main diagonal matrices, which correspond to the intraregional flows (Figure 4).

The states that have the most of the few links within the Amazon region are the ones of Amazonas and Mato Grosso, and to a less extent the states of Pará, Rondônia, and Maranhão.

Table 2. Share (%) of Interregional Imports in the Total Imports of a Given Region.

Region	AC	AP	AM	PA	RO	RR	TO	MA	MT	RBR
Acre (AC)		0.07	0.07	0.03	0.20	0.06	0.04	0.05	0.05	0.74
Amapá (AP)	0.04		0.04	0.08	0.02	0.05	0.04	0.05	0.01	0.65
Amazonas (AM)	4.30	3.05		4.08	6.97	9.29	1.45	2.07	3.22	49.55
Pará (PA)	0.47	0.98	1.76		0.43	0.55	2.02	3.78	0.34	13.04
Rondônia (RO)	3.61	0.24	3.20	0.13		0.81	0.15	0.17	0.71	3.83
Roraima (RR)	0.02	0.02	0.08	0.01	0.01		0.01	0.02	0.02	0.53
Tocantins (TO)	0.07	0.08	0.08	1.11	0.03	0.07		1.39	0.06	2.09
Maranhão (MA)	0.46	0.48	0.42	2.15	0.15	0.40	4.29		0.10	6.57
Mato Grosso (MT)	3.14	0.69	3.60	0.86	6.80	0.85	1.24	0.54		22.99
Rest of Brazil (RBR)	87.89	94.38	90.75	91.54	85.39	87.92	90.75	91.95	95.49	
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Research Data

Figure 2: Landscape of the Leontief Inverse for the Interregional System

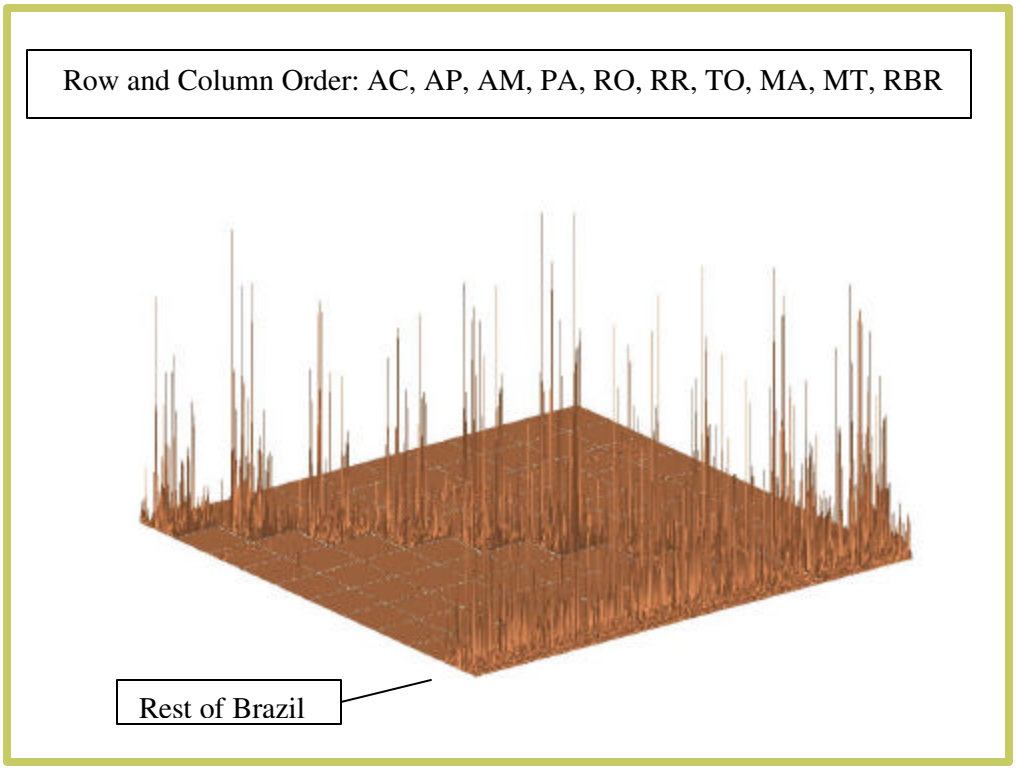


Figure 3: Landscape of the Leontief Inverse for the Interregional System, Without the Columns and Rows for the Rest of Brasil Region.

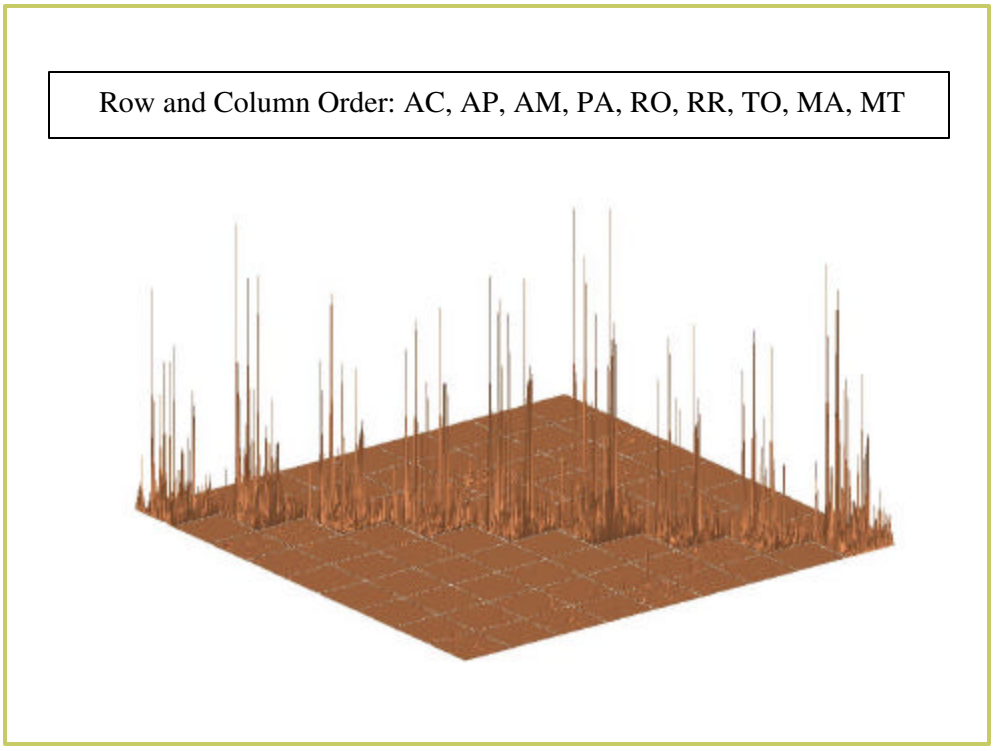
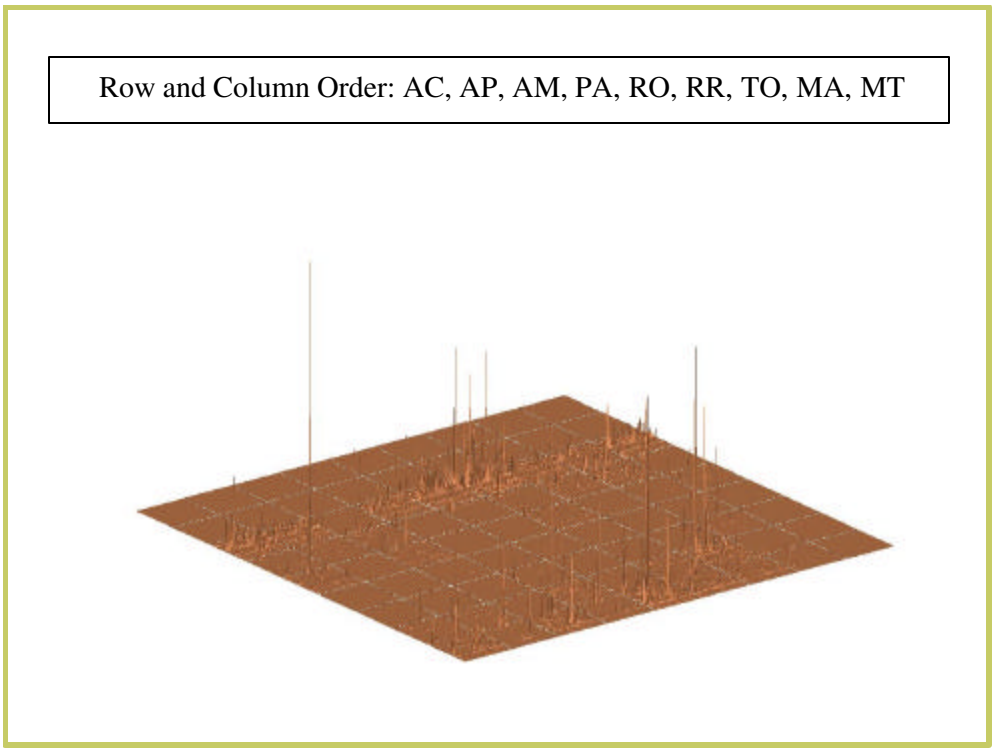


Figure 4: Landscape of the Leontief Inverse, Without: a) the Columns and Rows for the Rest of Brazil Region; and b) the Values for the Intraregional Flows.



The decomposition of the production multiplier for the Amazon region as whole (the interregional system for the 10 regions is aggregated now into a system of only two regions, the Amazon region and the Rest of Brazil) confirms the above analysis showing the regional dependence of the Amazon region to the other Brazilian states. Figures 5 and 6 show, respectively, the shares of each sector in each region on the production multipliers of the Amazon and the Rest of Brazil regions. One can see that the Amazon region shows a greater dependence on the other states, while the same is not true on the other way around.

To increase the production level in the Amazon region there is a need for an increase in production in the rest of the country, and, as a result there is an increase in employment and income in the Rest of Brazil. The same is not true concerning the other Brazilian sates, i.e., there is a small multiplier effect on the Amazon region as a result of a production increase in the rest of the economy

The same dependence showed for the region as whole can be seen by taking two of its more representative States as an example, i.e., the states of Amazonas and Pará. The results in Figures 7 and 8 show that the decomposition of these states multipliers show a small share of the Amazon region in its composition, stressing once more the low level of regional integration and a greater dependence on the rest of Brazil region.

Figure 5. Decomposition of the Production Multiplier, Type I, for the Industries in the Amazon Region.

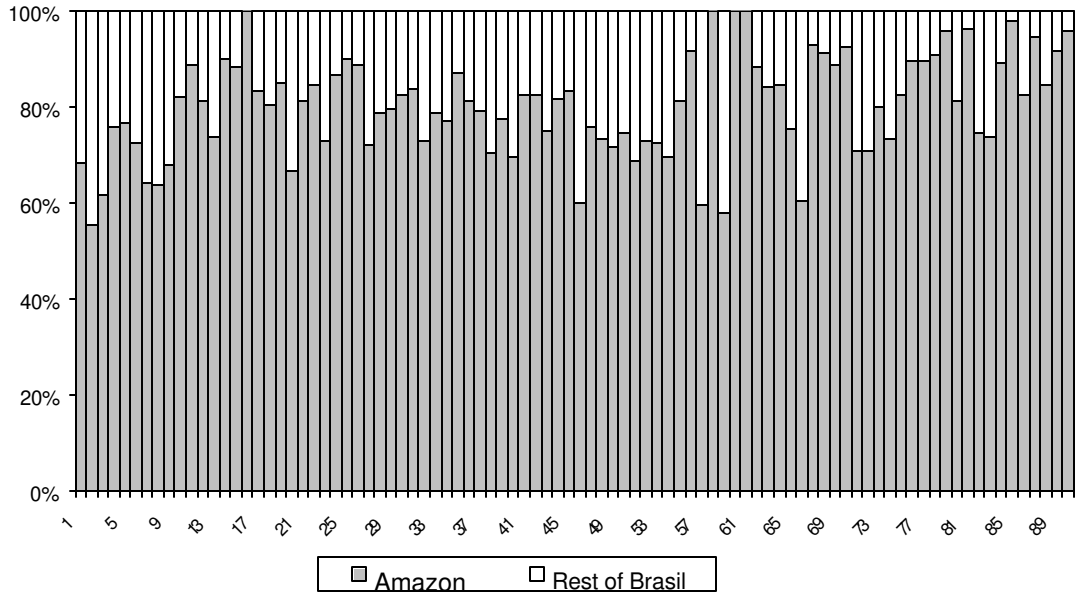


Figure 6. Decomposition of the Production Multiplier, Type I, for the Industries in the Rest of Brazil Region.

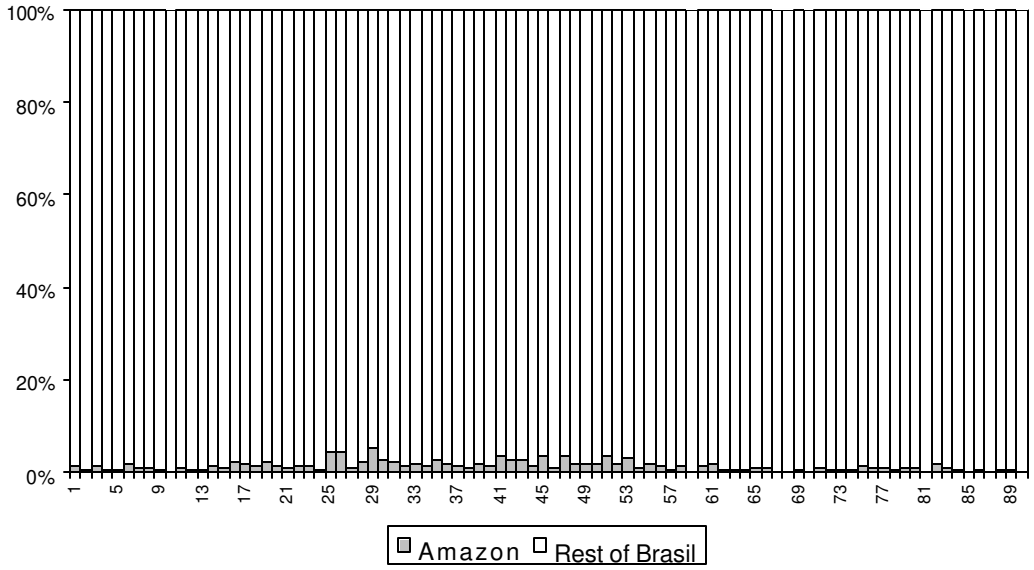
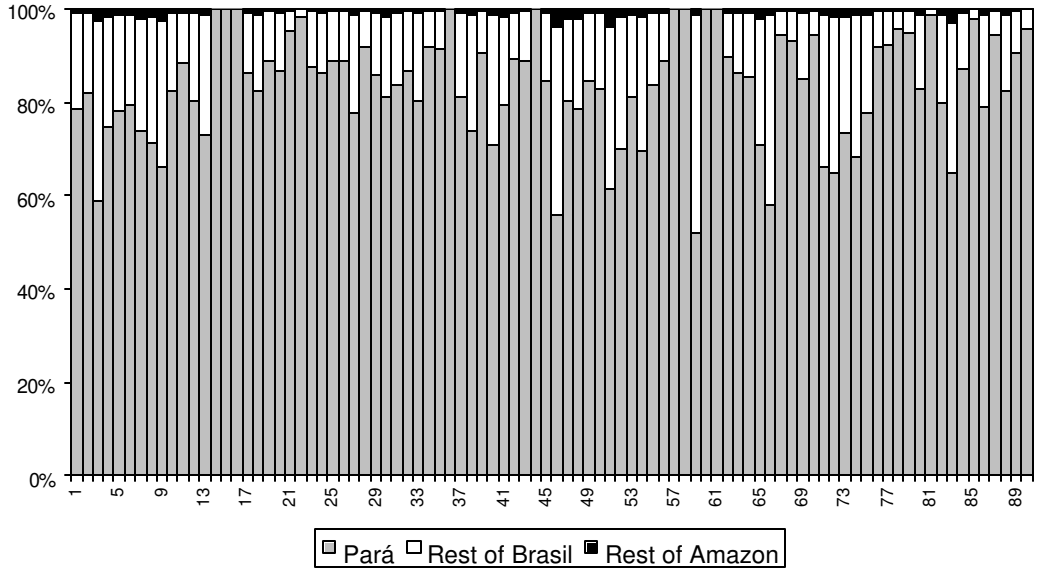


Figure 7. Decomposition of the Production Multiplier, Type I, for the Industries in the state of Amazonas.

Figure 8. Decomposition of the Production Multiplier, Type I, for the Industries in the state of Pará.



4.2. Differences in the Productive Structure, The Electroeconograms

Figures 9 to 14 show the Electroeconograms of the productive structure of the Amazon region. The concept of Electroeconogram is similar to the one for the electrocardiogram or the electroencephalogram in medicine that are used to measure the differences from a given standard. In that sense, using the Brazilian economy as a "numeraire" it is possible to examine how the results from a given region differ from the ones for the Brazilian economy. Then, one has that the higher the amplitude of the waves in the figures, the greater the difference in the productive structures.

In general one can observe that the Rest of Brazil region has values near zero, showing a greater similarity of this region with the country considered as a whole. This result was already expected given that the Rest o Brazil region has a share of around 93.5% of the Brazilian GDP.

The Amazon region shows states that differ in their productive structure, but it can also be observed similarities among the productive structure of the following states: Acre and Amapá; Amazonas and Pará; Rondônia, Roraima and Tocantins. The sates of Maranhão and Mato Grosso have, visually, productive structures relatively different from the other Amazon region states and between themselves.

Figure 9. Electroeconogram of Production Multipliers, Type I, for the Amazon Region Interregional System.

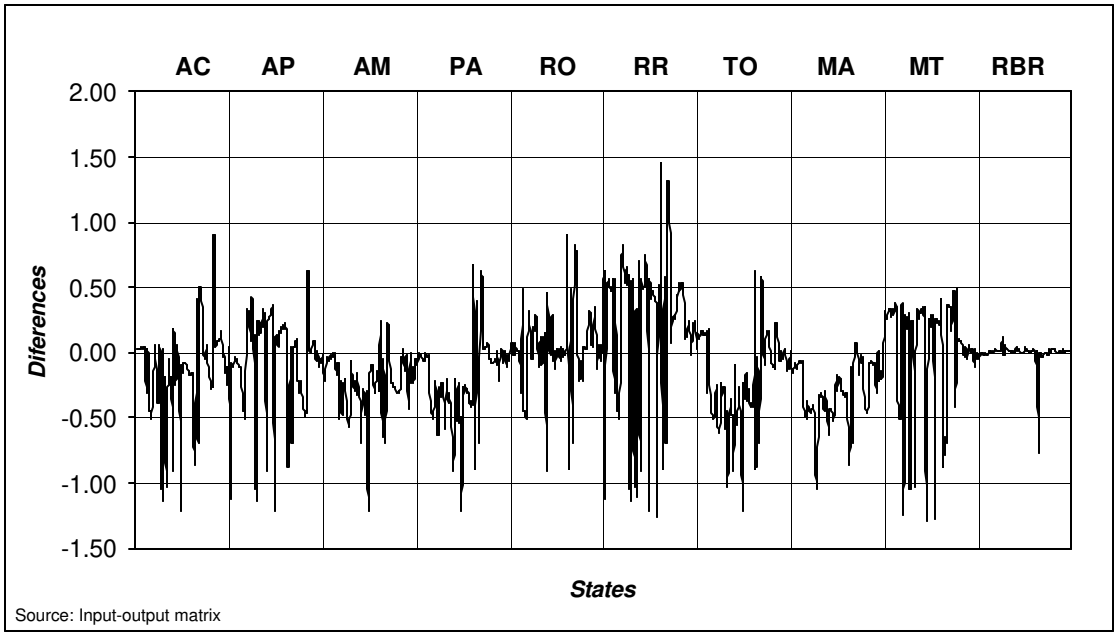


Figure 10. Electroeconogram of the Hirschman-Rasmussen Backward Linkages for the Amazon Region Interregional System.

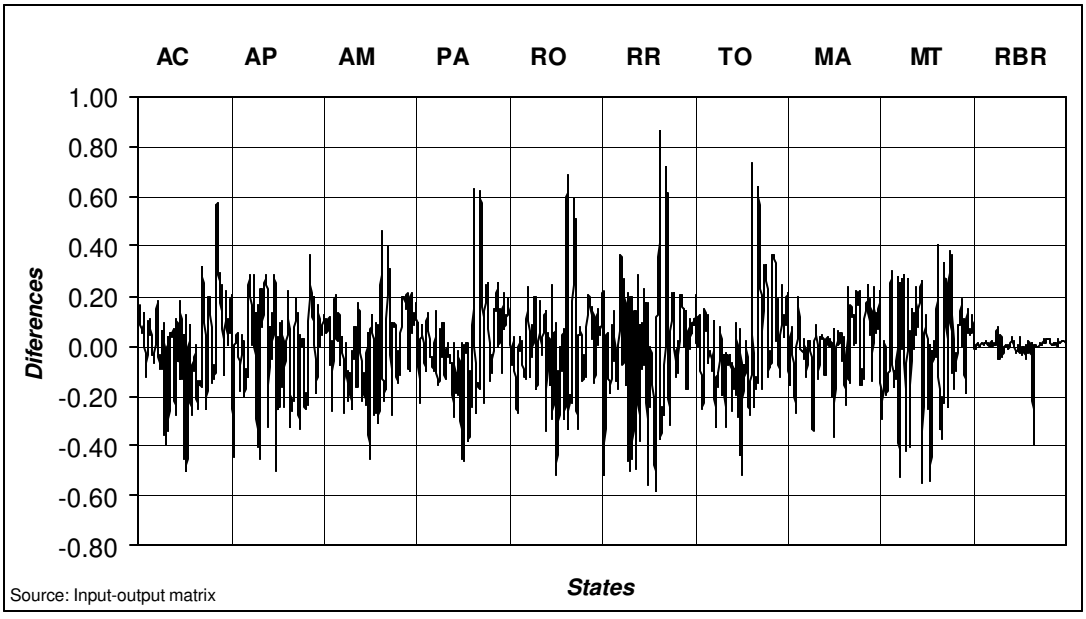


Figure 11. Electroeconogram of the Hirschman-Rasmussen Forward Linkages for the Amazon Region Interregional System.

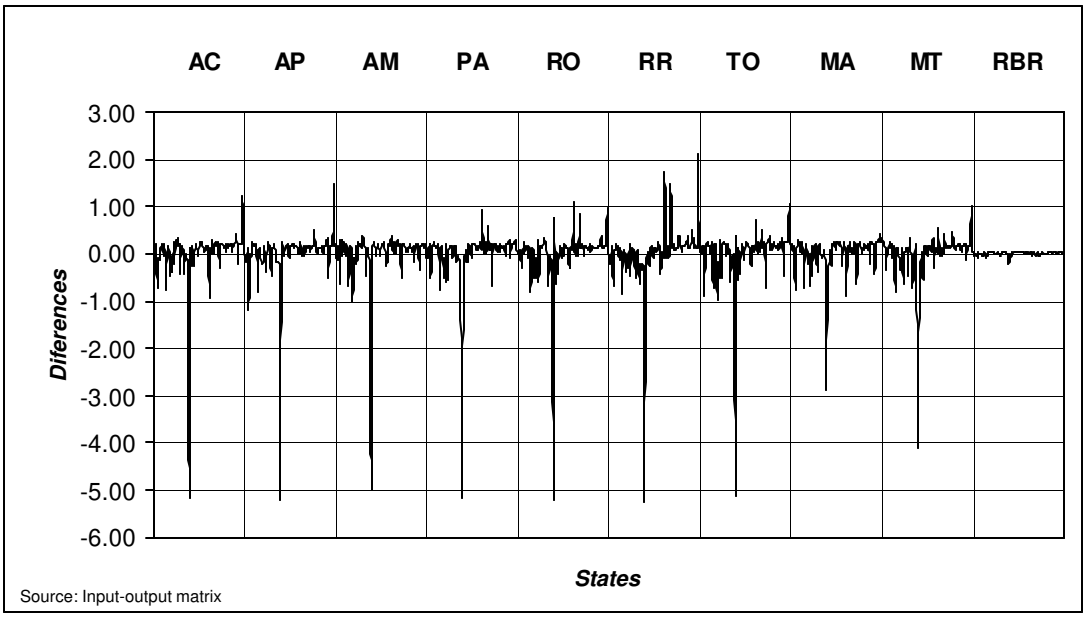


Figure 12. Electroeconogram of the Pure Normalized Backward Linkages for the Amazon Region Interregional System.

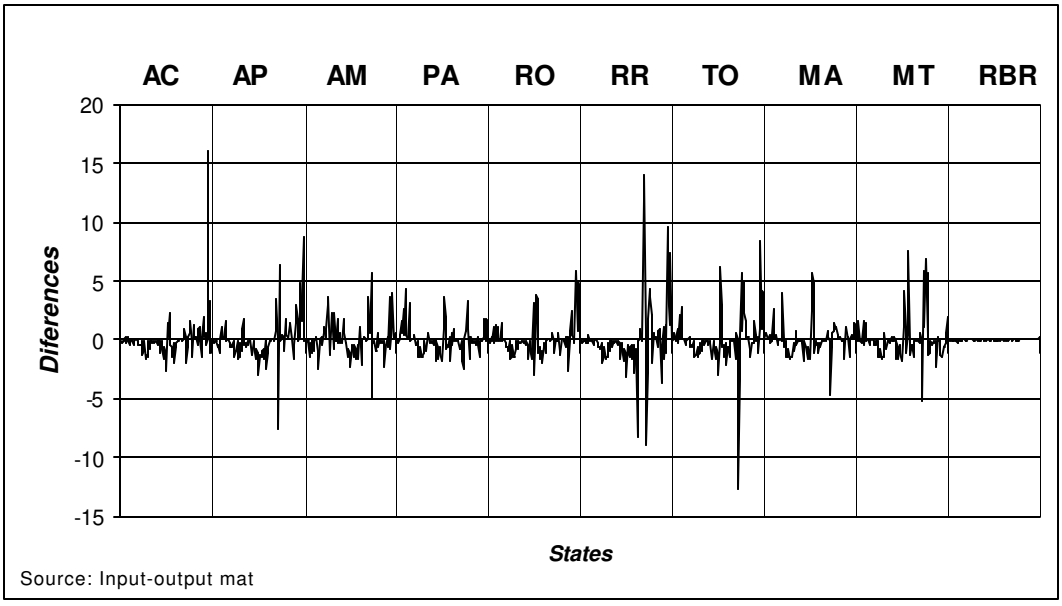


Figure 13. Electroeconogram of the Pure Normalized Forward Linkages for the Amazon Region Interregional System.

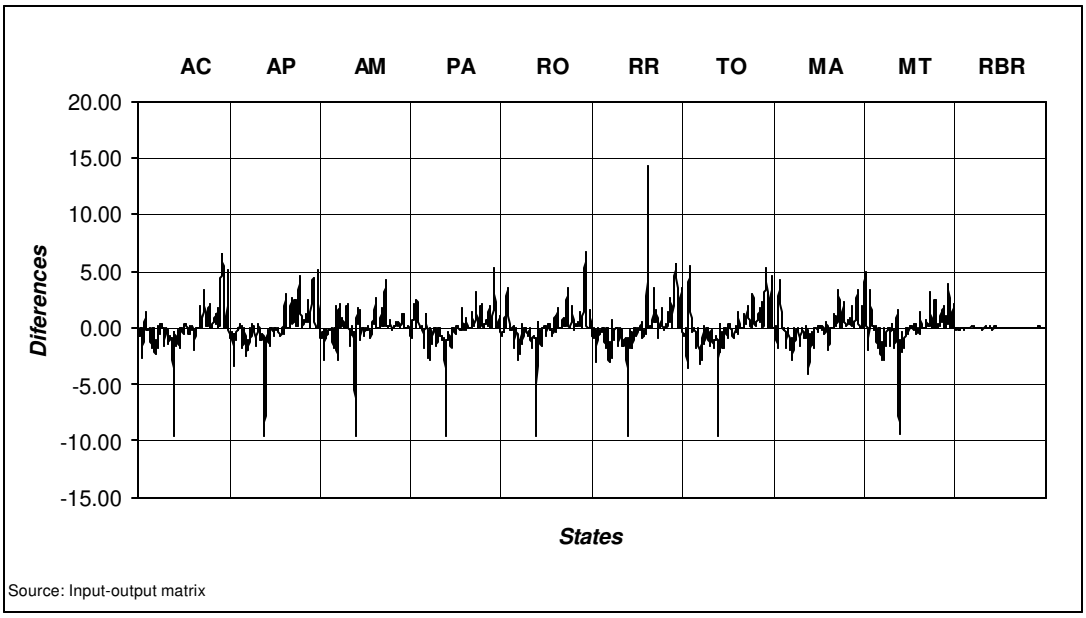
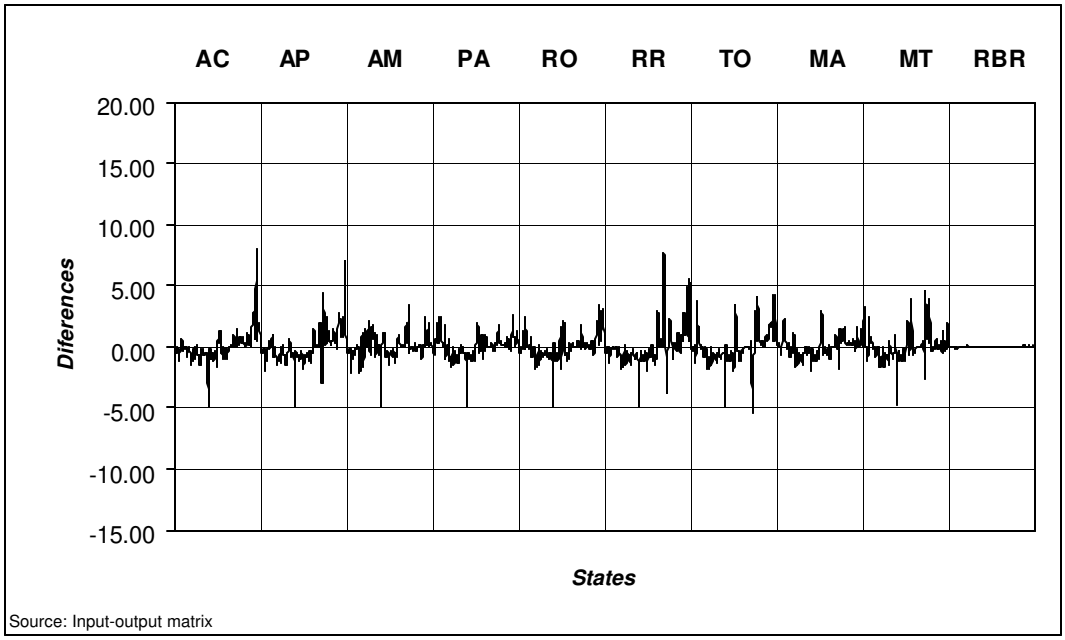


Figure 14. Electroeconogram of the Pure Normalized Total Linkages for the Amazon Region Interregional System.



6. FINAL COMMENTS

This study has show that the states of the Amazon region show a dependence on the Rest of Brazil region, given that the flow of goods and services between the region states and the Rest of Brazil are more intense than the flow among the region states. The decomposition of the production multipliers shows that the increase in production in any one of the 9 states of the Amazon region has a greater impact on the rest of the country than on the other states of the region.

There is a relative heterogeneity in the productive structure of the states of the Amazon region, however, a closer look of the data can show that some economic activities can be important for the economic and social development of the region as a whole. The analysis of the production multipliers and interindustry linkages direct for the importance of the following sectors: Wholesale, Civil Construction, and Services Rendered to the Families and to the Firms. Also, the set of sectors that compose the cluster of Tourism has a great potential of employment generation.

Despite that the sectors linked with agriculture have a secondary importance in the employment generation, investments in the food processing industries have a great potential of stimulating the region agribusiness and as consequence to generate growth and employment.

Investment in the food processing industries would allow the region to aggregate value to the production derived from the agriculture as well as the extractive sectors, increasing the value of the region exports and allowing for a process of transition from a economy highly dependable on the primary sector and on the service sector, mainly, through direct spending of the Federal government, to an economy based first into an agroindustrial system an then into an industrial system with higher level of linkage among the sectors and the states in the region.

REFERENCES

Guilhoto, J.J.M. et al (2002). "Projeto de Estimação de Matrizes de Insumo-Produto para a Região e os Estados da Amazônia Legal". Banco da Amazônia – BASA.

Guilhoto, J.J.M., M. Sonis, M., G.J.D. Hewings (1996). "Linkages and Multipliers in a Multiregional Framework: Integrations of Alternative Approaches.". *Discussion Paper,* 96-T-8 Regional Economics Applications Laboratory, University of Illinois, Urbana.

Hirschman, A.O. (1958) *The Strategy of Economic Development.* New Haven, Yale University Press.

IBGE (2002a). *Contas Regionais do Brasil, 1985-2000. Rio de Janeiro.*

IBGE (2002b). *Brasil em Números 2002*. Rio de Janeiro. Vol. 10.

Leontief, W. (1951). *The Structure of the American Economy*. Second Edition. New York: Oxford University Press.

Miller, R.E., e P.D. Blair (1985). *Input-Output Analysis: Foundations and Extensions.* Englewood Cliffs: Prentice-Hall.

Rasmussen, P. (1956) *Studies in Intersectoral Relations*. Amsterdam, North Holland.