# RELATIONS OF THE REGIONAL CANE AGROINDUSTRY WITH THE NATIONAL ECONOMY: ANALYSIS APPLIED TO THE CENTER-SOUTH AND NORTH-NORTHEAST[1]

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SUMMARY

The cane, sugar and ethanol production in Brazil has been divided in two major production regions, the Center-South (CS) and the North-Northeastern (NNE) Brazil. These regions present very different productivity, and henceforth production costs. The Center-South average productivity is higher than 72 tons of cane per hectare, while the average cane

[1] This work is part of a Ph.D. thesis of the first author: Cinthia Cabral da Costa.

production by hectare in the NNE is about 49 tons. The primary objective of the study was to set up the inter-relations between the cane agroindustry with other regional sectors and with the overall Brazilian economy. This framework was used to compare a demand impact of each regional cane agroindustry upon the regional and the overall Brazilian economy. An inter-regional input-output matrix was used to characterize how a regional demand impact affects both, the regional (CS and NNE) and overall Brazilian economies. Rasmussen-Hirschman indexes, together with a pure linkage index, described by Guilhoto et al. (1996), were used for the analysis. In addition, production multipliers, with and without considering endogenous family consumption were estimated. According to these indexes, a positive demand impact upon the cane agroindustry produces a greater impact upon the NNE compared to the CS economy, when income effects are considered, indicating that cane production is more important for the NNE economy than it is for the CS economy. These results can be useful to evaluate and establish priorities for development policies through public policy for the country.
Key-words: input-output matrix; inter-regional analysis; Brazil, cane agroindustry.

## 1. INTRODUCTION

Brazilian cane industry, which includes cane, sugar, and fuel ethanol production, has been historically concentrated in two main regions of the country: the North-Northeast (NNE) and the Center-South (CS). The NNE is characterized by low production and higher costs, while in the Center-South, cane production shows high productivity, great potential to expand and is identified as one of the lowest cost in a world context.

The difference in production capacity between these regions can also be characterized through its sugar and ethanol output. In the 2001/02 harvest year, the NNE was responsible for 17 percent of all the Brazilian production of sugar, and by 12 percent of the ethanol volume (including hydrated and anhydrous). This percentage was strongly decreased through the decade of the 90s and is expected to continue to decrease due to the process of the sector's deregulation that has been conducted by the Brazilian government. This evolvement shows the lower competitiveness of the NNE with respect to the CS in cane production.

There are several factors that explain the higher capacity of the Center-South Brazil to produce cane and its products, compared to the NNE. One of the most important, however, is its higher productivity, which is relevant to determine production costs. While in the NNE, the average productivity is about 49.5 tones of cane, while productivity results are much higher in the Center-South, with an average at 72.3 tones of cane by hectare.

There are clear signs that the regulation of the Brazilian cane sector maintained by the federal government, until the decade of the 90s, restricted the countries' export expansion.

The purpose of the study is to characterize the impact of the regional (CS and NNE) sugarcane agroindustry upon other economic sectors, on a regional, inter-regional and national basis. By indicating the importance of the sectors comprised by the cane agroindustry at each of these two regions, the results are useful to subsidize policies directed to promote regional development.

## 2. METHODOLOGY

An input-output inter-regional matrix was used to evaluate the differences between the sectors that constitute the cane industry of the Brazilian Center-South and of the North-Northeast regions. Initially, a comparative analysis of the sugar industry with the other sectors of the Brazilian economy was performed, involving the calculation of forward and backward Rasmussen-Hirschman and pure linkage indexes for all the economic sectors included in the input-output matrix. These indexes were used to evaluate the relative importance of each sector focused by the study, with respect to all others. The same can be done considering, for example, the sectors that are most related with the sugar industry. Production multipliers of type I and of type II were calculated for each of the two sugar exporting regions (CS and NNE) to evaluate the impact of an increase in final demand upon the Brazilian economy.

The input-output analysis is useful to understand the productive structure of a country or region. It is also adequate to study inter-relations between the economic sectors. The fundamental relations of the input-output model used for this study considers that the economy must be composed by *n* sectors, as shown in equation (1):

$$\sum_{j=1}^{n} z_{ij} + c_i + g_i + i_i + e_i = x_i \qquad ; \text{i} = 1, 2, \ldots \text{n} \tag{1}$$

where:

$z_{ij}$ = sector *i*'s production acquired by sector *j*;

$c_i$ = sector *i*'s production acquired by the families;

$g_i$ = sector *i*'s production acquired by the government;

$i_i$ = sector *i*'s production directed to investments;

$e_i$ = sector *i*'s production directed to exports;

$x_i$ = domestic production of sector *i*, composed by final demand and intermediate inputs.

The inter-regional analysis was developed based on a set of intra-regional (within a specific region) and inter-regional (between a given region and all others) input coefficients. This allows a more realistic inter-regional framework of the trade flow analysis for Brazil.

Technical coefficients were estimated for the inter-regional model, considering two regions, *L* and *M*. These are represented as follows:

$$a_{ij}^{LL} = z_{ij}^{LL} \big/ x_j^{L} \tag{2}$$

$$a_{ij}^{MM} = z_{ij}^{MM} \big/ x_j^{M} \tag{3}$$

$$a_{ij}^{LM} = z_{ij}^{LM} \big/ x_j^{M} \tag{4}$$

$$a_{ij}^{ML} = z_{ij}^{ML} \big/ x_j^{L} \tag{5}$$

where $a_{ij}^{LL}$ and $a_{ij}^{MM}$ are intra-regional technical coefficients; $a_{ij}^{LM}$ and $a_{ij}^{ML}$, are inter-regional technical coefficients; $z_{ij}^{LL}$ represents the monetary flow from sector *i* to sector *j,* within region *L*; $z_{ij}^{MM}$ represents the monetary flow from sector *i* to sector *j*, within region *M*; $z_{ij}^{LM}$ and $z_{ij}^{ML}$ are monetary flows from sector *i* to sector *j* and from region *L* to region *M,* and vice-versa, respectively; $x_j^{L}$ and $x_j^{M}$ represent total level of production for sector *j*, inside regions *L* and *M*, respectively.

A matrix of technical coefficients $A^{LL}$ can be constructed to represent the *n* sectors of Brazilian economy, such as:

$$A^{LL} = \begin{bmatrix} a_{11}^{LL} & a_{12}^{LL} & . & . & . & a_{1n}^{LL} \\ a_{21}^{LL} & a_{21}^{LL} & . & . & . & a_{2n}^{LL} \\ . & . & . & & & . \\ . & . & & . & & . \\ . & . & & & . & . \\ a_{n1}^{LL} & a_{n2}^{LL} & . & . & . & a_{nn}^{LL} \end{bmatrix} \tag{6}$$

The matrices $A^{LM}$, $A^{ML}$ and $A^{MM}$ can be represented in a similar form.

The Leontief system can be represented as:

$$\left\{ \begin{bmatrix} I & \vdots & 0 \\ \cdots & \cdots & \cdots \\ 0 & \vdots & I \end{bmatrix} - \begin{bmatrix} A^{LL} & \vdots & A^{LM} \\ \cdots & \cdots & \cdots \\ A^{ML} & \vdots & A^{MM} \end{bmatrix} \right\} \begin{bmatrix} x^{L} \\ \cdots \\ x^{M} \end{bmatrix} = \begin{bmatrix} Y^{L} \\ \cdots \\ Y^{M} \end{bmatrix} \tag{7}$$

where $Y^{L} = \left(I - A^{LL}\right)x^{L} - A^{LM}\,x^{M}$ e $Y^{M} = -A^{ML}\,x^{M} + \left(I - A^{MM}\right)x^{M}$. Matrices *A*, *X* e *Y*, can be estimated as follows:

$$A = \begin{bmatrix} A^{LL} & \vdots & A^{LM} \\ \cdots & \cdots & \cdots \\ A^{ML} & \vdots & A^{MM} \end{bmatrix}; \quad X = \begin{bmatrix} x^{L} \\ \cdots \\ x^{M} \end{bmatrix} \quad \text{and} \quad Y = \begin{bmatrix} Y^{L} \\ \cdots \\ Y^{M} \end{bmatrix}$$

The Leontief matrix can be estimated, starting by equation (7), which represents the major difference when an inter-regional matrix is used.

### 2.1 Rasmussen-Hirschman Linkage Indexes

Rasmussen (1956) and Hirschman (1958) defined linkage indexes between economic sectors that can be used to characterize those sectors that are highly dependent on other sectors, as input consumers or input suppliers. According to these authors, these main sectors can be identified by indexes higher than one. A sector with a backward linkage index higher than one is an input consumer, while those that present a forward linkage index higher than one, are input suppliers.

The indexes are defined based on equation $B = (I - A)^{-1}$, which expresses the inverse Leontief matrix. This equation considers a matrix *I*, which is an identity matrix, of the same order as matrix *A*, as defined by equation (7). Each element $b_{ij}$ element of matrix B. Can be used to define the matrix $B^*$, as an average of all the elements of *B*.

X The sums of the elements of a column and of a line of matrix *B* can be represented, in algebraic form, as:

$$B_{\bullet j} = \sum_{i=1}^{n} b_{ij} \tag{8}$$

$$B_{i\bullet} = \sum_{j=1}^{n} b_{ij} \tag{9}$$

where $i, j = 1, 2, \ldots, n$.

These sums are used to compose the Rasmussen-Hirschman Linkage Indexes. The backward linkage index, $H_j$, for example, related to input demand capacity, , can be obtained as:

$$H_j = \left[B_{\bullet j} / n\right] \Big/ B^* \tag{10}$$

The forward linkage index $H_i$, providing transmission capacity, can be represented as:

$$H_i = \left[B_{i\bullet} / n\right] \Big/ B^* \tag{11}$$

These indicators provide a measure of the relative capacity of a given sector to impact other sectors of the economy. When the value of $H_j$, the backward linkage index, is greater than 1, there is an indication that the *j* sector is an important consumer of the inputs provided by the other sectors of the economy under analysis. Whenever the value of $H_i$, the forward linkage index is higher than 1, there is an indication that the *i* sector is a major input supplier in the economy.

## 2.2 Pure indexes of inter-industry linkages

The pure linkage indexes, described by Guilhoto et. al. (1996), can be used as an alternative to the Rasmussen-Hirschman Linkage indexes, presented in the previous item. This should improve the index capacity of expressing the correct relation between the industries of a given economy by considering the relative size of production for the sectors of the economy under analysis.

The basic idea of the pure index, is to consider each economic sector in an isolate form, in order to identify the difference between total production of the economy when each of these sectors are included and when they are not. In a matrix form, the algebraic form of this index is demonstrated by equation (12). The pure linkage indexes can be calculated, starting by obtaining matrix $A$, which is composed by direct input coefficients, where the sector focused by the analysis is included together with the rest of the economy:

$$A = \begin{pmatrix} A_{jj} & A_{jr} \\ A_{rj} & A_{rr} \end{pmatrix} \tag{12}$$

where $A_{jj}$ and $A_{rr}$ are matrices that represent, respectively, the direct inputs of the *j* sector, and the direct inputs of the rest of the economy (*rr*), respectively; $A_{rj}$ represents matrices of direct inputs acquired by sector *j* from the rest of the economy; and $A_{jr}$ represents matrices from direct inputs purchased by the rest of the economy from sector *j*.

The inverse Leontief matrix, used above, is given by:

$$L = (I - A)^{-1} = \begin{bmatrix} L_{jj} & L_{jr} \\ L_{rj} & L_{rr} \end{bmatrix} = \begin{bmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{bmatrix} \begin{bmatrix} \Delta_{j} & 0 \\ 0 & \Delta_{r} \end{bmatrix} \begin{bmatrix} I & A_{jr}\Delta_{r} \\ A_{rj} & I \end{bmatrix} \tag{13}$$

such that each of its elements are:

$$\Delta_{j} = (I - A_{jj})^{-1} \tag{14}$$

$$\Delta_{r} = (I - A_{rr})^{-1} \tag{15}$$

$$\Delta_{jj} = (I - \Delta_{j} A_{jr} \Delta_{r} A_{rj})^{-1} \tag{16}$$

$$\Delta L_i = \left( \frac{L_i}{X_i} \right) \Delta X_i \tag{17}$$

The inverse Leontief matrix is obtained using matrix A, which includes sector j isolated from the rest of the economy. This matrix can be used to calculate:

$$X = (I - A)^{-1} \cdot Y \tag{18}$$

which represents a set of indexes that can be used to arrange the sectors, either in terms of the production value generated, as to verify how the production process of the economy operates. Equations (13) and (18) can be used to obtain the following equality:

$$\begin{pmatrix} X_j \\ X_i \end{pmatrix} = \begin{pmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{pmatrix} \begin{pmatrix} \Delta_j & 0 \\ 0 & \Delta_r \end{pmatrix} \begin{pmatrix} I & A_{jr}\Delta_r \\ A_{rj}\Delta_j & I \end{pmatrix} \begin{pmatrix} Y_j \\ Y_r \end{pmatrix} \tag{19}$$

Further multiplying the right side of the equation, it becomes:

$$\begin{pmatrix} X_j \\ X_r \end{pmatrix} = \begin{pmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{pmatrix} \begin{pmatrix} \Delta_j Y_j + \Delta_j A_{jr} \Delta_r Y_r \\ \Delta_r A_{rj} \Delta_j Y_j + \Delta_r Y_r \end{pmatrix} \tag{20}$$

The values of the pure backward linkage index (PBL) and of the pure forward linkage index (PFL), respectively, can be obtained as:

$$PBL = \Delta_r A_{rj} Y_j \tag{21}$$

$$PFL = \Delta_j A_{jr} \Delta_r Y_r \tag{22}$$

The pure backward linkage index represents the impact of the value of total production from sector j upon the rest of the economy, excluding the demand for its own inputs and the returns of the rest of the economy for this same sector.

The pure forward linkage index represents the impact of the value of total production from the rest of the economy upon sector *j*. The pure index of all the linkages is equal to the sum of the two indexes, that are expressed in current values as:

$$a_{ij}^{MM} = z_{ij}^{MM} \Big/ x_j^M \tag{23}$$

Since inter-regional matrices were used in this paper, the linkage indexes (pure and Rasmussen-Hirschman) were obtained following an interdependent form, such that its values carry the effects of the regional interactions. Algebraically, the indexes were calculated using matrix A described in equation (7).

## 2.3 Multipliers

The multipliers can be used to evaluate the impact of a change in the final demand upon the production level of the economy. In this work, production multipliers were calculated according to versions I and II. The direct, indirect, and induced impacts of family consumption upon production were obtained from the calculated multipliers

### a) Production multiplier of type I

Considering $B = (I - A)^{-1}$ from equation (7), the production multiplier of sector $j$ in the inter-regional matrix will be:

$$MS_j = \sum_{i=1}^{n} b_{ij}, \qquad j = 1,\ldots,n \qquad (24)$$

where $MS_j$ is the production multiplier of type I; and $b_{ij}$ is an element of the inverse Leontief matrix.

### b) Production multiplier of type II

The calculated production multipliers are obtained by considering family participation in final consumption, which depends on what is produced at each sector. In the case of multipliers of type II, the consumption of the family sector is transferred from the final demand to matrix $Z$ of intersectoral transactions. In this work, inter-regional transactions are also considered, such that an additional line and column is obtained. This rationale is meant to set the model such that it is closed with respect to the families.

In this case, the inverse Leontief $B$ matrix is obtained from a matrix $\overline{A}$ of technical coefficients, where the family consumption is considered endogenously, such that the sectoral multiplier is defined from matrix $\overline{B} = (I - \overline{A})^{-1}$. The production multiplier of type II is defined as:

$$M\overline{S}_j = \sum_{i=1}^{n} \overline{b}_{ij}, \qquad j = 1, \ldots, n \qquad (25)$$

where $M\overline{S}_j$ is the production multiplier of type II and $\overline{b}_{ij}$ is any element of the Leontief inverse matrix with family consumption considered endogenously.

## 2.4 Input-Output Matrix

The definition of the input-output matrix used for this work is important to obtain the results to be investigated in the present work. An inter-regional input-output matrix for Brazil was used for 1999. The regions considered were the Center-South and the North-Northeast. The inter-regional matrix used in the present study was obtained by Guilhoto[2], for 1999. The Center-South region includes the following states: Distrito Federal, Goiás, Mato Grosso, Mato Grosso do Sul, Espírito Santo, Minas Gerais, Rio de Janeiro, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul. All other Brazilian states are included in the North- Northeast region.

In general terms, the input-output matrix used in this analysis to represent the Brazilian economy, is more aggregated than the Brazilian input-output matrix divulged by the Instituto Brasileiro de Geografia e Estatistica – IBGE. The first is composed by 20 sectors (Table 1), while the later is composed by 42 sectors. The sectors focused by the study (particularly sugarcane and ethanol), however, were kept in a more disaggregated form, while others are considered in a more aggregated form.

| **Number** | **Name of the Sector in the Brazilian Matrix composed for this study (estimated with 1999 data)** | **Sectors presented in a more aggregated form than the IBGE matrix** |
|---|---|---|
| 1 | Sugarcane | Agriculture and Livestock |
| 2 | Rest of Agriculture and Livestock | |
| 3 | Extractive | Mineral extractive |
| | | Petroleum extraction and gas extraction |
| 4 | Metallurgy | Steel |
| | | Non- ferrous Metallurgy |
| | | Other metallurgy |

[2] GUILHOTO, J.J.M. (USP. FEA. Departamento de Economia, São Paulo). Personal communication, 2003.

| | | |
|---|---|---|
| 5 | Machines and tractors | |
| 6 | Electric and electronic material | Electric material |
| | | Electronic equipments |
| 7 | Transport material | Cars, trucks and buses |
| | | Other vehicles and parts |
| 8 | Wood, furniture, cellulose, paper and graphic | Wood and furniture |
| | | Paper and graphic |
| 9 | Ethanol | Chemical elements |
| 10 | Other chemical, not petrochemical elements | |
| 11 | Petroleum refining | |
| 12 | Products of petroleum refining | Various chemicals |
| | | Drugs and perfume |
| | | Plastic articles |
| 13 | Textile, clothes and footwear | Textile |
| | | Clothes |
| | | Footwear industry |
| 14 | Sugar industry | |
| 15 | Other food products | Coffee industry |
| | | Processed vegetal products |
| | | Animal slaughter |
| | | Dairy industry |
| | | Vegetable oils |
| | | Other food products |
| 16 | Other industries | Non metallic industry |
| | | Rubber industry |
| | | Other industries |
| 17 | Public utility industrial services | |
| 18 | Construction | |

| | | |
|---|---|---|
| 19 | Services to families | |
| 20 | Other services | Trade |
| | | Transport |
| | | Communication |
| | | Financial institutions |
| | | Services provided to firms |
| | | Rentals |
| | | Public administration |
| | | Non-tradable private services |

Table 1.1. Sectors included in the input-output matrix used for this paper.

## 3. RESULTS AND DISCUSSION

The objective of this work was to verify the inter-relations of the cane agroindustry with the overall Brazilian economy, and by region, Center-South and North-Northeast. For this purpose, some indexes that show the relationship between the economic sectors were presented. Rasmussen-Hirschman indexes, that measure the degree of linkage between sectors, were calculated. These were based in the demand for inputs from other sectors (backward indexes), and on input supplies to other sectors (forward linkages). These same relations were measured considering the production level existent in the economy through the pure linkage indexes. These indexes were obtained in an integrated way, considering sectoral sales and purchases at each region for all the Brazilian economy, and not only inside the region being analyzed. It was observed that the North-Northeast presented sales and purchase values considerably lower than those observed for the Center-South. Therefore, a way to avoid underestimating the importance of the North-Northeast in the economy was to consider the indexes weighted by the sectoral production levels of each region. Production multipliers types I and II, of the inter-regional matrix, are described in the following.

### 3.1 Analysis of the linkage indexes in the economy

The linkage indexes was calculated to show the inter-relationship between the economic sectors of the Center-South and North-Northeast Brazil, indicating the most important sectors that supply and demand inputs in the economy, which are indicated, respectively as forward linkage index and backward linkage index. The indexes show the production impact of each sector, and for each of the analyzed regions, upon the overall

By another side, the Rasmussen-Hirschman indexes estimate the importance of the sectors, without considering the production level of each of these. The pure linkage indexes consider, however, the production value of each sector and therefore are considered a more realistic expression of the relative importance of each sector inside the economy. Two indexes were estimated and compared.

#### 3.1.1 Rasmussen-Hirschman linkage indexes

The forward and backward Rasmussen-Hirschman indexes, calculated for all sectors that compose the inter-regional matrix for Brazil (defined for the Center-South and North-Northeast regions) are presented in Figures 1 and 4. The backward linkage indexes relate the sectors of the inter-regional matrix that purchase production from other sectors of the national economy. The forward linkage indexes measure the inter-relation of each sector as an input supplier for all other sectors of the economy.

The results related to the highest backward linkage indexes indicate that in both regions (the CS and the NNE), these follow a same order of importance for a given set of sectors, which are identified as: 4 – metallurgy [BL[3]-CS = 1.24; BL-NNE = 1.28]; 15 – other food products [BL-CS = 1.215; BL-NNE = 1.256]; 14 – sugar industry [BL-CS = 1.206; BL-NNE = 1.256]; e 13 – textile, clothes and footware [BL-CS = 1.16; BL-NNE = 1.18].

[3] Value calculated for the Rasmussen-Hirschman backward linkage index.

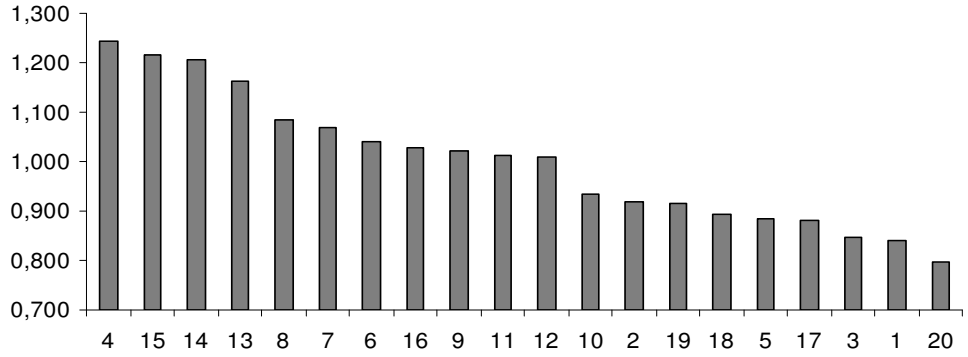


Figure 1 – Rasmussen-Hirschman backward linkage index (BL) for the Center-South (CS) sectors.

Source: Research results.

Note: sector 1 – Sugarcane; sector 2 – Rest of the agriculture and livestock; sector 3 – Extractive; sector 4 – Metallurgy; sector 5 – Machines and tractors; sector 6 – Electric and electronic material; sector 7 – Transport material; sector 8 – Wood, furniture, cellulose, paper, and graphic; sector 9 – Ethanol production; sector 10 – Other chemical and petrochemical; sector 11 – Petroleum refining; sector 12 – Products of petroleum refining; sector 13 – Textile, clothes and footware; sector 14 – Sugar industry; sector 15 – Other food products; sector 16 – Various industries; sector 17 – Public utility industrial services; sector 18 – Civil construction; sector 19 – Services provided to families; sector 20 – Other services.

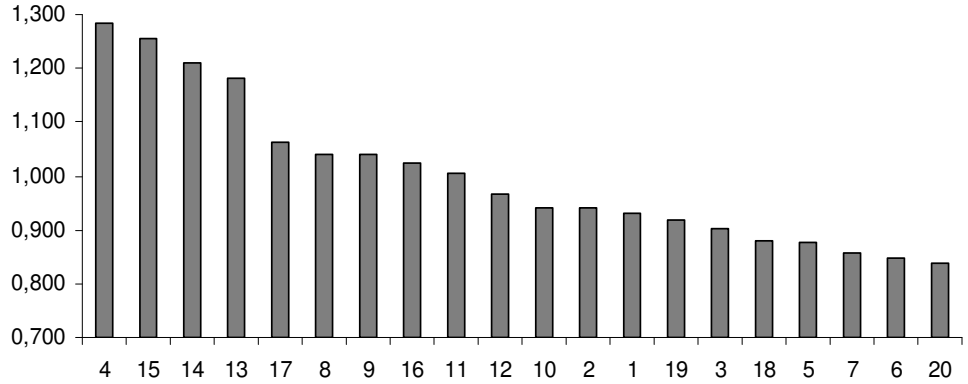


Figure 2 – Rasmussen-Hirschman backward linkage index (BL) for the North-Northeast (NNE) sectors.

Source: Research results.

Note: sector 1 – Sugarcane; sector 2 – Rest of the agriculture and livestock; sector 3 – Extractive; sector 4 – Metallurgy; sector 5 – Machines and tractors; sector 6 – Electric and electronic material; sector 7 – Transport material; sector 8 – Wood, furniture, cellulose, paper, and graphic; sector 9 – Ethanol production; sector 10 – Other chemical and petrochemical; sector 11 – Petroleum refining; sector 12 – Products of petroleum refining; sector 13 – Textile, clothes and footware; sector 14 – Sugar industry; sector 15 – Other food products; sector 16 – Various industries; sector 17 – Public utility industrial services; sector 18 – Civil construction; sector 19 – Services provided to families; sector 20 – Other services.

Therefore, there is an indication that the four sectors that determine the highest demand for inputs from other economic sector is the sugar industry. This provides a dimension of the relative importance of an expansion of that sector, either by selling in the domestic market or to the international market to stimulate growth in the other economic sectors.

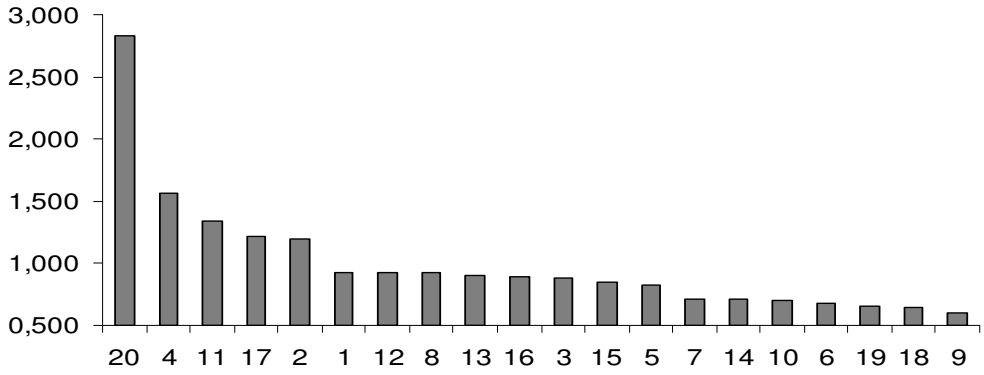


Figure 3 – Rasmussen-Hirschman forward linkage index (FL) for the Center-South (CS) sectors.

Source: Research results.

Note: sector 1 – Sugarcane; sector 2 – Rest of the agriculture and livestock; sector 3 – Extractive; sector 4 – Metallurgy; sector 5 – Machines and tractors; sector 6 – Electric and electronic material; sector 7 – Transport material; sector 8 – Wood, furniture, cellulose, paper, and graphic; sector 9 – Ethanol production; sector 10 – Other chemical and petrochemical; sector 11 – Petroleum refining; sector 12 – Products of petroleum refining; sector 13 – Textile, clothes and footware; sector 14 – Sugar industry; sector 15 – Other food products; sector 16 – Various industries; sector 17 – Public utility industrial services; sector 18 – Civil construction; sector 19 – Services provided to families; sector 20 – Other services.

The highest values for the forward linkage index, among the CS sector, in a decreasing order were: sector 20 – other services [FL[4] = 2.83]; sector 4 – metallurgy [FL = 1.567]; sector 11 – oil refining [FL = 1.343]; 17 – Public utility services [FL = 1.22]; and sector 2 - rest of agriculture and livestock sector [FL = 1.195].

In a similar form, these sectors also presented the greatest indexes in the North-Northeast (Figure 4), however in a different order of importance: sector 20 – other services [FL = 2.6]; sector 17 – Public utility services [FL = 1.39]; sector 4 – metallurgy [FL = 1.377]; sector 2 – rest of agriculture and livestock [FL = 1.25]; and sector 11 – oil refining [FL = 1.14].

[4] Value calculated for the Rasmussen-Hirschman forward linkage index.

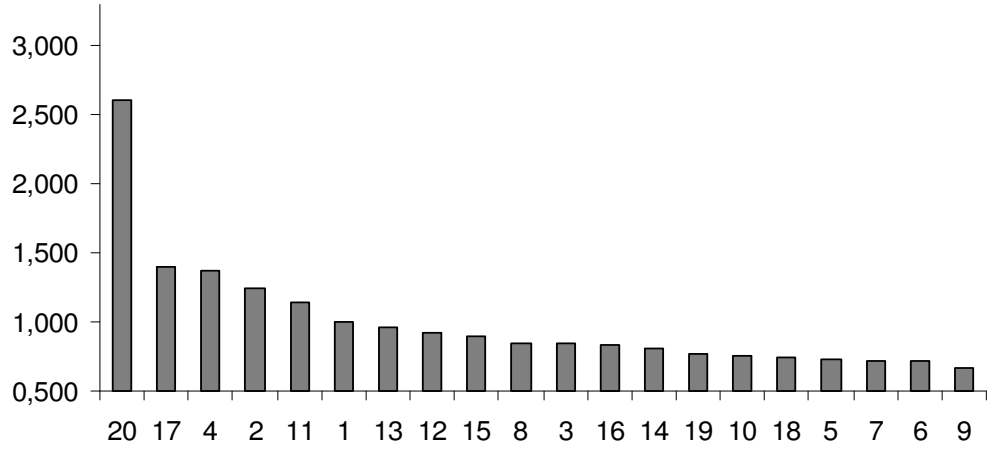


Figure 4 – Rasmussen-Hirschman forward linkage index (FL) for the North-Northeast (NNE) sectors.

Source: Research results.

Note: sector 1 – Sugarcane; sector 2 – Rest of the agriculture and livestock; sector 3 – Extractive; sector 4 – Metallurgy; sector 5 – Machines and tractors; sector 6 – Electric and electronic material; sector 7 – Transport material; sector 8 – Wood, furniture, cellulose, paper, and graphic; sector 9 – Ethanol production; sector 10 – Other chemical and petrochemical; sector 11 – Petroleum refining; sector 12 – Products of petroleum refining; sector 13 – Textile, clothes and footware; sector 14 – Sugar industry; sector 15 – Other food products; sector 16 – Various industries; sector 17 – Public utility industrial services; sector 18 – Civil construction; sector 19 – Services provided to families; sector 20 – Other services.

It must also be taken into account that various sectors have been aggregated, such that the sectors that were taken in a disaggregated form (such as sugar, ethanol and cane) were in relative disadvantage in terms of absolute value of purchase and sales. The opposite occurred for some sectors such as sector 20 (other services), taken in a very aggregated form, therefore presenting values much higher compared to those of the other sectors.

The sectors can also be evaluated using the criteria that key sectors of the economy are those that present index values greater than one, expressing that their index is greater than the average obtained for all the other sectors of the economy. It can be seen that, in both regions, the sugar industry (sector 14) and ethanol production (sector 9) were key backward sectors for the economy. This means that their demand is higher than the average in the Brazilian economy, at each of the regions analyzed. This means that the sectors that demand more of the Brazilian economy than the average demanded by the other sectors of those regions.

It is interesting to notice, however, that the cane sector in the Center-South did not seem to be a key sector in terms of forward linkage indexes, contrary do what was verified for the North-Northeast sector. This indicates that in the Center-South, the average of the suppliers of products for the Brazilian economy was higher than the cane supply.

Comparing the regions, it can be verified that the sectors that presented the most differentiated index values were: sector 6 – electric and electronic material e 7 – transport material. These were key demanding sectors for inputs in the Center South Brazil, while in the NNE, their importance was not expressive. Sector 17 – Public utility services was a key sector for the NNE, presenting the fifth highest backward index, impacting the input demand of the economy by 1.063. However, this sector was of lower importance in the CS, showing an impact index of 0.88 in that region.

In both regions, cane production (sector 1) appears as an important input supplier for the Brazilian economy, among the six greatest, according to the forward linkage index (FL). For the CS, the FL assumes a 0.927 value for the CS and 1.007 for the NNE, according to the sectoral aggregation used in this paper. In a similar form, ethanol production (sector 9), and sugar industry (sector 14) showed the highest values for the backward linkage index (BLI). In both regions, sugar production was the third highest BL index value [BL-CS = 1.206; BL-NNE = 1.211]. Sector 9 was the relatively more important in the NNE, ranking as the seventh highest value [BL-NNE = 1.039], while in the Center-South it was the ninth greatest value [BL-CS = 1.022]. A comparison between sugar and ethanol production suggests that there are greater advantages for the Brazilian economy when sugarcane is used for sugar production instead of ethanol production.

### 3.1.2 Pure linkage index

Guilhoto et al. (1996) proposed some alternative indexes that show the impact of a given sector upon others, taking their relative production size into account.

Since these are estimated from an inter-regional matrix, the pure linkage indexes for a given sector in the CS, for example, show the pure production impact of this sector upon the other sectors of the Brazilian economy and upon the sectors of the Center-South region. A non-dimensional numeraire, obtained by normalization with respect to the

production value, was used to compose this index. The value of the region analyzed was used as the weight. This is required to estimate importance of the NNE regional sectors within the region, such that these can be properly compared to those of the CS. Figures 5, 6, 7 and 8 present the values calculated for the pure forward and backward linkages, as well as their respective order, considering the regions of the Brazilian inter-regional matrix used for the analysis. These results show the differences between the two regions of the country, as purchasers and suppliers of inputs for the economy.

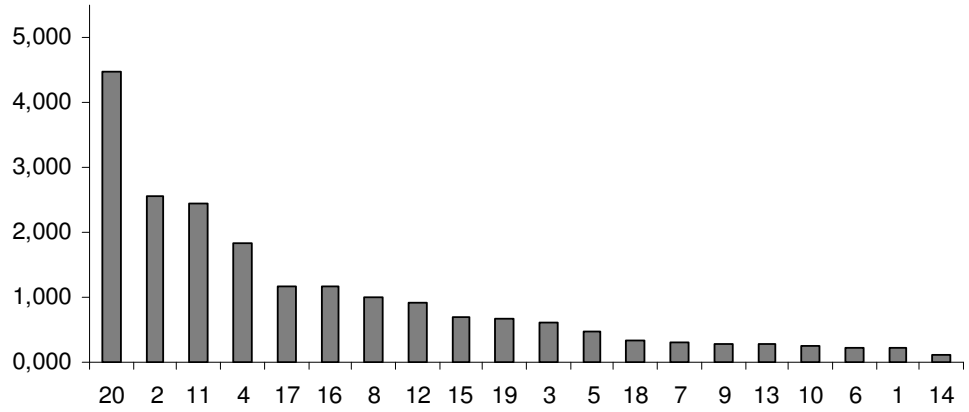


Figure 5 – Pure forward linkage index (PFL) for the Center-South (CS) region.

Source: research results.

Note: sector 1 – Sugarcane; sector 2 – Rest of the agriculture and livestock; sector 3 – Extractive; sector 4 – Metallurgy; sector 5 – Machines and tractors; sector 6 – Electric and electronic material; sector 7 – Transport material; sector 8 – Wood, furniture, cellulose, paper, and graphic; sector 9 – Ethanol production; sector 10 – Other chemical and petrochemical; sector 11 – Petroleum refining; sector 12 – Products of petroleum refining; sector 13 – Textile, clothes and footware; sector 14 – Sugar industry; sector 15 – Other food products; sector 16 – Various industries; sector 17 – Public utility industrial services; sector 18 – Civil construction; sector 19 – Services provided to families; sector 20 – Other services.

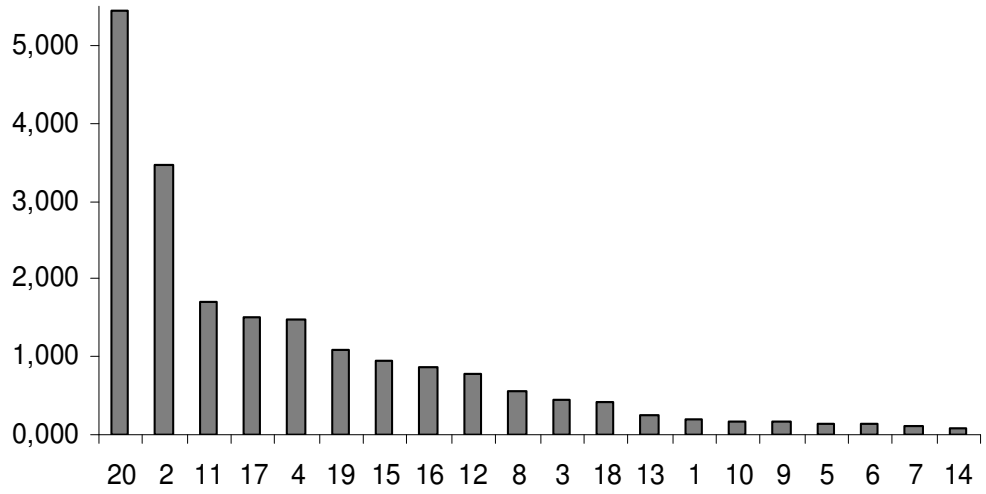


Figure 6 – Pure forward linkage index (PFL) for the North-Northeast (NNE) region.

Source: research results.

Note: sector 1 – Sugarcane; sector 2 – Rest of the agriculture and livestock; sector 3 – Extractive; sector 4 – Metallurgy; sector 5 – Machines and tractors; sector 6 – Electric and electronic material; sector 7 – Transport material; sector 8 – Wood, furniture, cellulose, paper, and graphic; sector 9 – Ethanol production; sector 10 – Other chemical and petrochemical; sector 11 – Petroleum refining; sector 12 – Products of petroleum refining; sector 13 – Textile, clothes and footware; sector 14 – Sugar industry; sector 15 – Other food products; sector 16 – Various industries; sector 17 – Public utility industrial services; sector 18 – Civil construction; sector 19 – Services provided to families; sector 20 – Other services.

The results show that the sectors which presented the highest values for the forward pure linkage indexes (key sectors as input suppliers for the economy), were the same compared to those described by the Rasmussen-Hirschman indexes, at both regions. This leads to the conclusion that there is no conflict between the two methodologies.

In a decreasing order, the sectors that presented the highest pure forward linkage (PFL) indexes for both regions were: sector 20 – other services [PFL-CS = 4.474; PFL-NNE = 5.447]; sector 2 – rest of agriculture and livestock [PFL-CS = 2.544; PFL-NNE = 3.46]; and sector 11 – petroleum refining [PFL-CS = 2.45; PFL-NNE = 1.7]. Sector 4 – metallurgy was the fourth highest in the CS [PFL-CS = 1.847] and the fifth in the NNE economy [PFL-NNE = 1.476]. Sector 17 – SIUP, was the fourth greater supplier in the NNE economy, according to the pure forward linkage index [PFL-NNE = 1.5] and the fifth

in the CS [PFL-CS = 1.159]. In general, the indexes calculated in these sectors were higher than those described for the Rasmussen-Hirschman index.

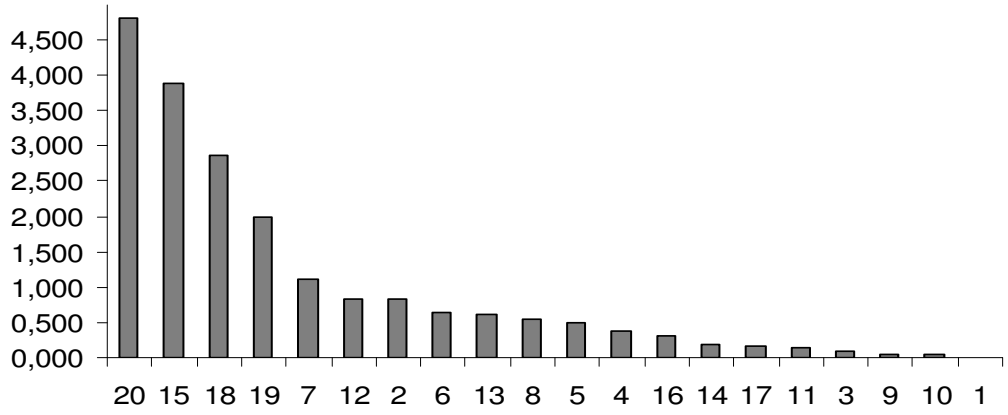


Figure 7 – Pure backward linkage index (PBL) for the Center-South (CS) region.
Source: research results.

Note: sector 1 – Sugarcane; sector 2 – Rest of the agriculture and livestock; sector 3 – Extractive; sector 4 – Metallurgy; sector 5 – Machines and tractors; sector 6 – Electric and electronic material; sector 7 – Transport material; sector 8 – Wood, furniture, cellulose, paper, and graphic; sector 9 – Ethanol production; sector 10 – Other chemical and petrochemical; sector 11 – Petroleum refining; sector 12 – Products of petroleum refining; sector 13 – Textile, clothes and footware; sector 14 – Sugar industry; sector 15 – Other food products; sector 16 – Various industries; sector 17 – Public utility industrial services; sector 18 – Civil construction; sector 19 – Services provided to families; sector 20 – Other services.

While comparing the PBL index with the Rasmussen-Hirschman, only sector 15 – Other food products, was among the main sectors demanding economic inputs of those regions (CS e NNE). The economic sectors of the CS that presented PBL indexes higher than 1 were: sector 20 – other services [PBL = 4.81]; sector 15 – other food products [PBL = 3.88]; sector 18 – Civil construction [PBL = 2.869]; sector 19 – public services provided for families [PBL = 1.979]; and sector 7 –transport material [PBL = 1.109]. The main input demanding sectors in the NNE were: sector 15 – other food products [PBL = 4.66]; sector 20 – other services [PBL = 4.30]; sector 18 – civil construction [PBL = 3.798]; sector 19 – services provided for families [PBL = 2.615]; and sector 2 – rest of agriculture and livestock [PBL = 1,185]. Therefore, while the transport material was very important in the CS, with respect to total demand in the Brazilian economy, this sector was of less

importance in the NNE. The rest of agriculture and livestock, however, was a key input demanding sector only in the NNE.

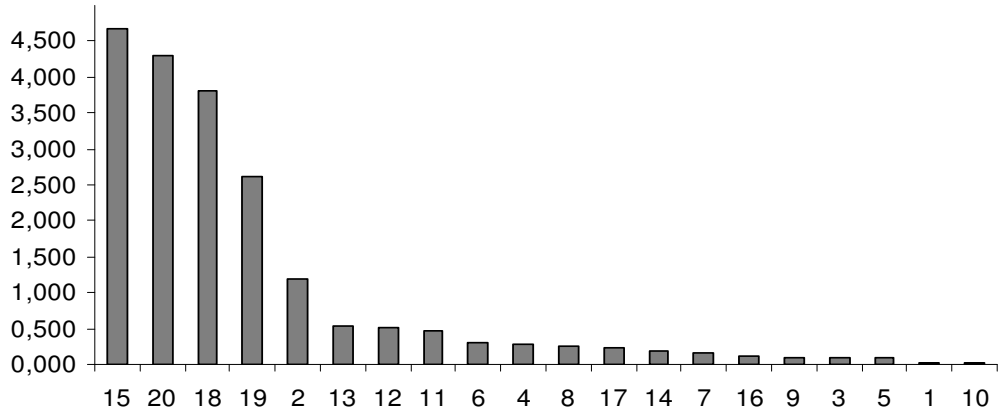


Figure 8 – Pure backward linkage index (PBL) for the North-Northeast (NNE) region.
Source: research results.

Note: sector 1 – Sugarcane; sector 2 – Rest of the agriculture and livestock; sector 3 – Extractive; sector 4 – Metallurgy; sector 5 – Machines and tractors; sector 6 – Electric and electronic material; sector 7 – Transport material; sector 8 – Wood, furniture, cellulose, paper, and graphic; sector 9 – Ethanol production; sector 10 – Other chemical and petrochemical; sector 11 – Petroleum refining; sector 12 – Products of petroleum refining; sector 13 – Textile, clothes and footware; sector 14 – Sugar industry; sector 15 – Other food products; sector 16 – Various industries; sector 17 – Public utility industrial services; sector 18 – Civil construction; sector 19 – Services provided to families; sector 20 – Other services.

Sector 14 – sugar production and sector 9 – ethanol production, were not identified as key input demanding sectors in the Brazilian economy by the pure indexes. This results contrast, however, with those obtained by applying the Rasmussen-Hirschman index. The cane production, sector 1, has also not been identified as a key sector for product supply in the Brazilian economy in the two regions analyzed.

The results of the linkage indexes for the economy led to the conclusion that the cane agroindustry sectors (which includes cane, sugar and ethanol sectors) have a higher importance in the NNE than in the CS.

### 3.2 Production multipliers of type I and of type II

The linkage indexes, presented and discussed in the previous item, provide an indication of the relevance of the sectors at each region as input suppliers and demanders in the Brazilian economy. The total effect upon economic production and employment results from the impacts estimated in the first part of this work, which were calculated based upon the Leontief multiplier. This item presents the results of the estimates obtained for the multiplier of type I (MS1) and of type II (MS2), considering the two regions in the inter-regional matrix used for the analysis.

Figures 9 e 10 describe the results of the calculation of the type I and type II multipliers in the Brazilian inter-regional matrix, related to the CS and NNE regions, respectively. The production multipliers indicate the production impact in the Brazilian economy, caused by a change in the final demand at each sector and region. The major difference between the multipliers of type I and of type II, is that in the second, family consumption is incorporated as an additional economic sector and no more as one of the vectors that compose final demand. This implies that the total impact calculated by the multiplier of type II is always greater than the multiplier of type I.

The difference (presented as a vertical measure in Figures 9 e 10) between the MS2 and the MS1 values in the sector of the region being evaluated shows the income effect of the impact of an increase in final demand of that specific sector for that region. This allows one to verify that the income effect was more important to stimulate the Brazilian economy, at each of the regions under analysis.

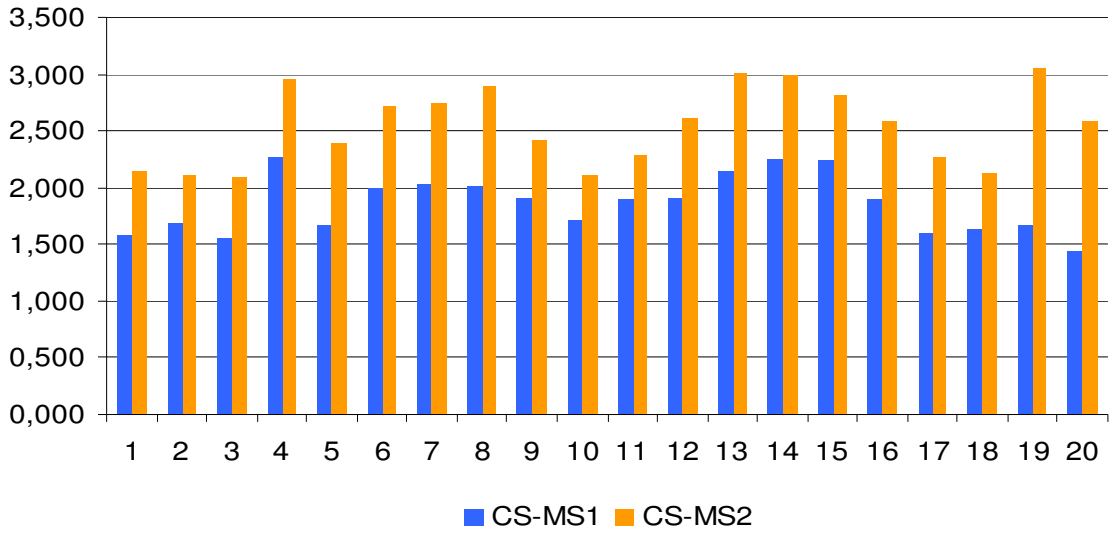


Figure 9 – Production multipliers of type I (MS1) and type II (MS2), about the Brazilian economy, related to an increase in the final demand of the Center-South sectors.

Source: research results.

Note: sector 1 – Sugarcane; sector 2 – Rest of the agriculture and livestock; sector 3 – Extractive; sector 4 – Metallurgy; sector 5 – Machines and tractors; sector 6 – Electric and electronic material; sector 7 – Transport material; sector 8 – Wood, furniture, cellulose, paper, and graphic; sector 9 – Ethanol production; sector 10 – Other chemical and petrochemical; sector 11 – Petroleum refining; sector 12 – Products of petroleum refining; sector 13 – Textile, clothes and footware; sector 14 – Sugar industry; sector 15 – Other food products; sector 16 – Various industries; sector 17 – Public utility industrial services; sector 18 – Civil construction; sector 19 – Services provided to families; sector 20 – Other services.

An evaluation of the production multipliers of type I show that in both regions, the same sectors were responsible for the four greatest multipliers in the economy. The highest multipliers, in a decreasing order, were: Sector 4 – metallurgy [MS1-CS = 2.270; MS1-NNE = 2.319]; sector 14 – sugar industry [MS1-CS = 2.257; MS1-NNE = 2.255]; sector 15 – other food products [MS1-CS = 2.24; MS1-NNE = 2.189]; and sector 13 - textile, clothing and footware [MS1-CS = 2.145; MS1-NNE = 2.141]. The value of the type I production multiplier for sector 8 - wood, furniture, cellulose, paper and graphic was identified as the fifth greatest in the NNE, assuming a value of 1.862. In the CS it was the sixth greatest value of type I production multiplier (equal to 2.009), followed by sector 7 – transport material [MS1-CS = 2.031]. Transport material was much less important in the NNE [MS1-NNE = 1.722], assuming a value lower than the equivalent for twelve other

sectors. This relatively higher importance assumed by the transport sector in the CS was also identified by the BL indexes already discussed.

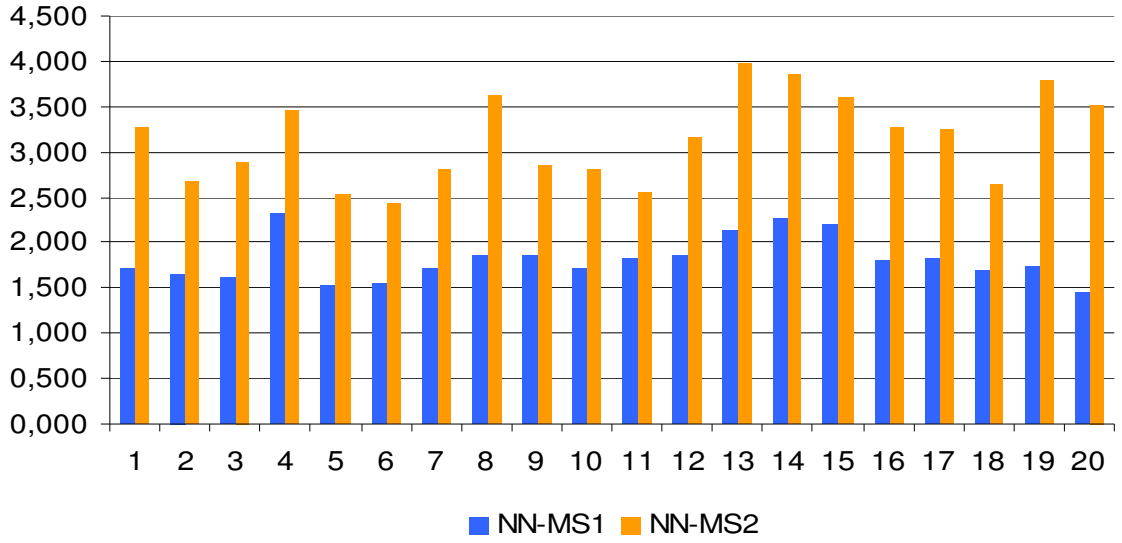


Figure 10 – Production multipliers of type I (MS1) and of type II (MS2), for the Brazilian economy related to a final demand increase in the NNE sectors.

Source: result research.

Note: sector 1 – Sugarcane; sector 2 – Rest of the agriculture and livestock; sector 3 – Extractive; sector 4 – Metallurgy; sector 5 – Machines and tractors; sector 6 – Electric and electronic material; sector 7 – Transport material; sector 8 – Wood, furniture, cellulose, paper, and graphic; sector 9 – Ethanol production; sector 10 – Other chemical and petrochemical; sector 11 – Petroleum refining; sector 12 – Products of petroleum refining; sector 13 – Textile, clothes and footware; sector 14 – Sugar industry; sector 15 – Other food products; sector 16 – Various industries; sector 17 – Public utility industrial services; sector 18 – Civil construction; sector 19 – Services provided to families; sector 20 – Other services.

Focusing on the results for the Center-South region, the sectors that presented higher production multipliers of type II, in a decreasing order of importance were: sector 19 – services provided for families; sector 13 – textile, clothing and footware; sector 14 – sugar industry; sector 4 – metallurgy; and sector 8 – wood, furniture, cellulose, paper and graphic. These sectors caused an increase in production in the Brazilian economy of about three times, when their final demand is increased (MS2 varied from 3.06 to 2.89 in these sectors).

In the North-Northeast, the sectors that presented the highest values for the production multipliers of type II were: sector 13 - textile, clothing and footware [MS2 =

3.986]; sector 14 – sugar industry [MS2 = 3.845]; sector 19 – services provided for families [MS2 = 3.787]; sector 8 - wood, furniture, cellulose, paper and graphic [MS2 = 3.615]; and sector 5 – other food products [MS2 = 3.607]. As shown by the values in brackets, an initial shock in any of these sectors will result in an impact superior to 3.5 times in the Brazilian economy.

Within the cane agroindustry, the sugar industry shows the highest production multiplier value of type I and of type II, for both regions. The type I multiplier values for sector 1 – cane production; sector 9 – ethanol production and sector 14 – sugar industry, were very similar in the two regions. The values obtained for production multipliers of type II, however, were in general, much higher in the NNE economic sectors than in the CS. These results can be explained, considering that income level in the NNE is lower than in the CS, which makes the first region more sensitive to an income change.

Similar to what was determined by the Rasmussen-Hirschman linkage index, the production multipliers indicated a greater importance of sector 14 - the sugar industry compared to sector 9 - ethanol production. The production multipliers show that in both, CS and NNE regions, the impact of an increase in ethanol final demand in the ethanol industry is about 80 percent of the impact estimated by an increase in sugar demand.

The results of production multipliers in the economy lead to the conclusion that, complementary to the linkage indexes, an impact of the NNE cane, sugar and ethanol agroindustry upon the Brazilian economy is higher than when the same impact is provoked in the CS.

## 4. CONCLUSIONS

Since Brazil is a continental country and has significant technological and behavioral differences between regions that produce and export a given product, the regional analyzes of the impacts caused by a demand shock in the Brazilian economy is very important. This study demonstrates that, by one side, a highest impact in the Brazilian NNE than in the CS region, when the family income effect is incorporated into the analysis and the number of employment generated is the result. The linkage indexes calculated for the CS and NNE sectors indicated that the relative importance of the cane agroindustry is

similar for both regions. Sector 1 (sugarcane production) was the only sector with Rasmussen-Hirschman index results that differed between the regions evaluated. This sector was one of the most important input suppliers for the NNE economy, while the same was not verified for the Center-South. Therefore, it can be concluded that the cane agroindustry is more important for the CS than for the NNE.

It was also noticed that the effect of a demand shock (direct, indirect and income induced effect) at the NNE sugar agroindustry had a higher impact upon the Brazilian economy compared to what was observed from a demand shock in the CS. This confirms the results obtained for the linkage indexes.

This information is important to subsidize the Brazilian government in choosing alternative policy decisions for regional development. It can be concluded that the Center-South region should be stimulated, if the government chooses to promote the more competitive region, since the potential of obtaining a higher returns for the country is greater. If this is the case, however, alternative plans to develop the NNE region should also be considered, focusing potentially competitive sectors.

An alternative strategy that can be considered by the Brazilian government is to adopt a development plan for the North-Northeast, by stimulating sugar export production and exports. This would be justified since the impact of a demand increase in that region is greater for the Brazilian economy than if it occurred in the Center-South. This policy would imply in a reduction of the relative concentration of the sugar market in the Center-South.

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