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Interdependence among the Brazilian States: an Input-Output approach[1]

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ABSTRACT

The principal aim of this paper is to evaluate the interregional linkages based on the many-region input-output table for Brazilian regions, for the year 1996, elaborated by FIPE. This work utilizes the extraction method by Strassert, 1968 and Schultz, 1977 and modified by Dietzenbacher *et al* (1993). Instead of extracting one sector from a sector-based model, we will examine the effects of hypothetically extracting a region from a many-region model. The method calculates the "backward linkages"; the "forward linkages" are obtained analogously from the matrix of allocation coefficients. The application of the methodology to the Brazilian inter-regional input-output tables shows that the states with high share in the Brazilian GDP presents a high degree of intra-regional interdependence both in terms of backward and forward linkages.

Key words: interregional input-output, linkages, regional economics.

JEL classification: R15, R58

1. Introduction

The idea of sectoral dependence, sectoral linkages and regional interdependence is presented in the input-output literature in different ways. Hirschman (1958) analyzed sectoral dependence from the demand side (exploring backward effects) while Cella (1984) focused on the supply side (forward effects). Chenery and Watanabe (1958) measured the backward effects by reference to the direct coefficient matrix *A* only while Rasmussen (1958) and Hirschman (1958) promoted the notion of a key sector. These ideas were further extended by Sonis and Hewings (1994) in the development of the concept of Fields of Influence to verify if the impact of a coefficient change (technology change) was concentrated in one or two other sectors or more broadly diffused throughout the economy.[5] A parallel development was the improvement in the Cella (1984) and Clements (1990) idea, which is the notion of pure linkages made by Guilhoto *et al* (1994) and Sonis *et al* (1995).

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[5] For further example of the application of the methodology of linkages, Key sector and Fields of Influence for the Brazilian economy, see Sonis, *et al* (1995) and Haddad (1999).

Another interesting way to compute linkages is by means of the method of hypothetical extraction. The original method of hypothetical extraction (Strassert, 1968) involves calculating the difference in output when an individual sector is removed from an economy. The size of the difference will indicate the importance of the sector that was hypothetically isolated in the economy context (Dietzenbacher *et al*, 1993). Based on the original method of extraction, it is impossible to discriminate between backward and forward linkage effects.

The literature also presents several different approaches for the extraction method. Cella (1984) proposed an improvement on the original method. Instead of starting with the two types of linkages (backward and forward) the author defined first the total linkages effect of a specific industry and then sought to identify the other two components. The measure of total linkages proposed by Cella (1984) has the following characteristics: a) it was constructed based on a consistent input-output model of the economy with a fixed set of technical coefficients, b) it is possible to split the result into two components (backward and forward linkage) and c) it does not include the feedback process that are intrinsic to the selected industry[6].

However Clements (1990) argued that the decomposition of linkages proposed by Cella (1984) overestimated the forward linkages. According to Clements (1990) the second part of Cella's forward linkages measure is really a part of backward linkages. In order to solve (or minimize) this problem, Clements (1990) proposed a new disaggregation of total linkages.[7]

The regional extraction method, which will be presented in more detail in the next section,[8] makes some adaptations to Strassert's original method. Instead of extracting a sector, we will implement a regional extraction (one at a time) in the interregional input-output model. Hence, we can examine how the isolation of one region will affect production in the rest of the economy. It also allows the differentiation between backward[9] and forward[10] linkages. According to Miller and Lahr (2001) there is a place for separate backward and forward linkage indicators in a cross-economy comparison of economic structure (*i.e* in this paper, across regions in a multiregional economy). With the purpose of reaching this aim, the extraction will occur precisely in these linkages. In order to calculate the backward linkages of a sector (or region), all intermediate deliveries that this sector

[6] For more details see Cella (1984).
[7] For more details see Clements (1990).
[8] The method is based on Dietzenbacher *et7 al* (1993).
[9] The backward dependence of a buying region (or sector) with respect to a selling region (sector).
[10] The forward dependence of a selling region (or sector) with respect to a buying region (sector).

(or region) buys are hypothetically extracted. For the forward linkages, all the intermediate deliveries that a sector (or region) sells are extracted. Based on these steps, it is possible to calculate the backward linkages of the isolated region, and also indicate the dependence of this region upon the inputs from the rest of the economy. The forward linkages are derived in a dual manner. Instead of using the input coefficients matrix (matrix *A*) we will use the output coefficients (allocation matrix).[11]

Miller and Lahr (2001) examine all possible extractions and also speculate on the plausibility of the economic significance that might underpin them. The authors pointed out that a number of alternative extractions produce identical results for certain measures of sectoral importance.

Hence, the framework described earlier, when implemented in a multi-regional input-output matrix, will enable us to analyze, in detail, the structure of the Brazilian states economic interactions. It is important to highlight that the interactions in this paper will be treated as the trade among the Brazilian states. Hence, before presenting the results we will describe the methodology and we will highlight briefly some points discussed in the literature about the importance of trade for development.

2. Regional Extraction Method[12]

Consider the general case of an interregional input-output model with *N* regions and *n* productive sectors in each region.[13] The model is given by:

$$x = Ax + f \qquad (1)$$

where: x – the nN-element column output vector.

A – the $nN \times nN$ matrix of input coefficients.

f – the nN-element column vector of final demand.

The solution of equation (1) will be:

$$x = (I - A)^{-1} f \quad or \quad Lf$$

$$where \;\; L = (I - A)^{-1} \; is \; the \; Leontief \; Inverse$$

The output vector is partitioned as follows[14].

[11] For further applications of this method see Van Der Linden (1998), Dietzenbacher and Van Der Linden (1997) and Sonis, *et al* (2000).

[12] This section is based on Dietzenbacher, *et al* (1993).

[13] The regions will be represented by superscripts $I,J = 1,\ldots,N$ and the products by subscripts $i, j = 1,\ldots, n$.

[14] The vector f can be partitioned in the same way.

$x = (x^{1'}, ..., x^{I'}, ..., x^{N'})$

$where\ x^I = (x^I_1, ...x^I_i, ...x^I_n)'$

The coefficient matrix is constructed as follows:

$$A = \begin{bmatrix} A^{11} & \cdots & A^{1N} \\ \vdots & \ddots & \vdots \\ A^{N1} & \cdots & A^{NN} \end{bmatrix} \quad (2)$$

The extraction method considers the effect of hypothetically isolating one region on the output of the rest of the economy. Without loss of generality, consider the case where the first region was extracted. Thus, the remaining *N-1* regions will represent the rest of the economy.[15] Hence, we can write $x = (x^{1'}, x^{R'})'$ *with* $x^R = (x^{2'}, ..., x^{I'}, ..., x^{N'})'$ a *n(N-1)* element column vector.

In a similar way, we have:

$$A = \begin{bmatrix} A^{11} & A^{1R} \\ A^{R1} & A^{RR} \end{bmatrix} \quad (3)$$

Analogous to the equation (3), the Leontief inverse in its partitioned form is given by:

$$L = (I - A)^{-1} = \begin{bmatrix} L^{11} & L^{1R} \\ L^{R1} & L^{RR} \end{bmatrix} \quad (4)$$

Based on the equation (4) we have:

$$x^1 = L^{11} f^1 + L^{1R} f^R \quad (5a)$$

$$x^R = L^{R1} f^1 + L^{RR} f^R \quad (5b)$$

With the hypothetical extraction of region 1, the model in equation (1) will assume the form:

$$\bar{x}^R = A^{RR} \bar{x}^R + f^R$$

The vector $\bar{x}^R$ represents the production of the rest of the economy with the first region removed. The solution of the reduced equation is:

$$\bar{x}^R = (I - A^{RR})^{-1} f^R \quad (6)$$

The difference between x^R (equation 5b) and $\bar{x}^R$ (equation 6) provides the extraction effect of region 1 upon the product of the rest of the economy. In order to interpret the elements of vector $x^R - \bar{x}^R$, we have to calculate the matrix *L* as the inverse of partitioned matrix[16] as follows:

$$L^{1R} = L^{11} A^{1R} (I - A^{RR})^{-1} \quad (7a)$$

$$L^{R1} = (I - A^{RR})^{-1} A^{R1} L^{11} \quad (7b)$$

[15] In order to represent these regions we will use the superscript *R*.

[16] For a detailed discussion about the portioning structure see Miller and Lahr (2001).

$$L^{RR} = (I - A^{RR})^{-1} + (I - A^{RR})^{-1} A^{R1} L^{11} A^{1R} (I - A^{RR})^{-1} \quad (7c)$$

Hence we have:

$$x^R - \bar{x}^R = L^{R1} f^1 + \left[L^{RR} - (I - A^{RR})^{-1} \right] f^R \quad (8a)$$

$$= (I - A^{RR})^{-1} A^{R1} L^{11} \left[f^1 + A^{1R} (I - A^{RR})^{-1} f^R \right] \quad (8b)$$

The interpretation of the expression $x^R - \bar{x}^R$ can be divided into two parts: the first one $\left(L^{R1} f^1 \right)$ describes the production in the rest of the economy that is necessary to satisfy the final demand f^1 in region 1 and the second part, $\left[L^{RR} - (I - A^{RR})^{-1} \right] f^R$, describes the production in the rest of the economy $L^{RR} f^R$ that is necessary to satisfy the final demand in the rest of the economy f^R.

We can observe that the elements of vector $x^R - \bar{x}^R$ show the interdependence between region 1 and the other regions. According to Dietzenbacher *et al* (1993), these interdependencies are fundamentally backward in their nature. These can be demonstrated using the matrix A^{R1} (whose elements indicate the backward dependence of *1* on *R*) and A^{1R} (whose elements indicate the backward dependence of *R* on *1*).

In order to better understand the expression $x^R - \bar{x}^R$, we will use the equation (8b) and examine this equation using the idea of interregional spillover effect and interregional feedback effects developed by Miller and Blair (1985). In order to satisfy the final demand f^1 in region 1, this region must produce $L^{11} f^1$. Region 1 does not have all the inputs necessary to reach this level of production. So, with the aim of achieving this production, it is necessary that region 1 purchases inputs direct from the other regions. The amount of inputs purchased will be $A^{R1} L^{11} f^1$. To provide these inputs, the production in the rest of the economy that is required is $\left(I - A^{RR} \right)^{-1} A^{R1} L^{11} f^1$. The same analysis can be made for the demand in the rest of the economy f^R.

Applying the traditional idea of interregional feedbacks to region 1, it is possible to affirm that the feedbacks for this region will be obtained by comparing the outputs of region 1 within the interregional model to the outputs of region 1, within the single-region model. Essentially we have:

$$x^1 - \bar{x}^1 = L^{11} f^1 + L^{1R} f^R - \left(I - A^{11} \right)^{-1} f^1 \quad (9)$$

Taking the equations (7) and (8) and interchanging the superscripts *1* and *R* we will have:

$$x^1 - \bar{x}^1 = \left(I - A^{11}\right)^{-1} A^{1R} L^{RR} \left[f^R + A^{R1} \left(I - A^{11}\right)^{-1} f^1 \right] \quad (10)$$

Based on the regional extraction framework it is possible to affirm that the vector $x^1 - \bar{x}^1$ measures the backward dependence of the rest of the economy on the region 1. In other words, the vector enables us to measure the impact of extracting, from the economy, all the *N-1* regions in *R* upon the output of the remaining region 1.

2.1 Forward Linkages

Turning to the forward linkage effects, consider the accounting equation $x = Te + f$, where $T -$ is the matrix of intermediate deliveries, e is the summation column vector, $e = (1,1,...,1)^{/}$, $f -$ is the final demand vector and $x -$ is the vector of total production, it is possible to define $x = Ax + f$, where $A = T\hat{x}^{-1}$.

The matrix *B* (the allocation matrix) can be defined as follows:

$$B = \hat{x}^{-1} T \quad (11)$$

In similar way, the accounting equation $x^{'} = e^{'}T + v^{'}$, where $v' -$ is the row vector of primary inputs imply that:

$$x^{/} = x^{/} B + v^{/} \quad (12)$$

Which can be rewritten as:

$$x^{/} = v^{/} \left(I - B\right)^{-1} = v^{/} G \quad (13)$$

The equation (1) presents the demand driven input-output model and the equation (12) is the dual form of equation (1) and can be taken as supply driven input-output model. The forward linkages can be obtained based on the vector $\left(x - \bar{x}\right)^{'}$. We can implement the extraction (or isolation) of one region. When the region 1 is extracted we will have:

$$\left(x - \bar{x}\right)^{/} = \left[\left(x^1 - \bar{x}^1\right)^{/}, \left(x^R - \bar{x}^R\right)^{/} \right]$$

$$= \left(v^{1^{/}}, v^{R^{/}}\right) \left\{ \begin{bmatrix} G^{11} & G^{1R} \\ G^{R1} & G^{RR} \end{bmatrix} - \begin{bmatrix} \left(I - B^{11}\right)^{-1} & 0 \\ 0 & \left(I - B^{RR}\right)^{-1} \end{bmatrix} \right\} \quad (14)$$

Hence, the vector $\left(x^R - \bar{x}^R\right)'$ will represent the forward linkages of region 1 upon the rest of the economy and the vector $\left(x^1 - \bar{x}^1\right)'$ will represent the forward linkages of the rest of the economy upon region 1.

3. Interactions and development: a brief comment

"The relevant problem of regional economic development (...) revolves around a region's ability to become integrated into the larger markets of the world through exports (...)" North (1959). North's (1959) ideas will be explored in this paper through an examination of a region's exports and its comcomitant with the external. Without an extensive time series of data on exports, it would be difficult to venture any causal relationship between exports and development. In the present paper, foucs on the nature and spatial structure of interdependence among the Brazilian states.[17]

Thus, according to North it is possible to consider the idea that trade works as an engine of growth. His idea is linked to the export base theory. According to North (1975), the existence of outside demand is a necessary condition for regional growth. On the other hand, considerations concerned with location, such as comparative advantage in production and transfer costs can be taking as sufficient conditions for economic development.

According to Herckscher-Ohlin-Samuelson (H-O-S) theorem, trade results from differences in relative factor endowments. Thus, if a country's production is intense in labor it will export labor-intensive goods. It is important to highlight that in the early 1960's the literature pointed out some limitations in the capacity of H-O-S theorem to explain some trade patterns. During that period there was the recognition that a growing percentage of the quickly rising volume of world trade was occurring between advanced countries with similar factor endowments (*e.g.* intraindustry trade). On the other hand, the theorem is still able to explain the trade between developing and developed countries.

In order to explain the intraindustry trade Krugman (1975) and Helpman and Krugman (1985) developed a theory that was based on the existence of increasing returns to scale and imperfect competition. According to the authors, these factors will provide reasons for specialization and

[17] As far as we understand the regional development may be correlated also with the interaction between the Brazilian states and other countries. But, the main aim of this paper is the internal interaction.

trade. They also pointed out that the intrafirm and intraindustry trade between advanced countries will occur mainly in industries characterized by scale economies and oligopolistic market structures.

Hence, as summarized by Magalhães *et al* (2000), *"countries at early stages of economic development tend do behave according to the H-O-S theorem, i.e., by exporting the goods in which they have comparative advantage. So, it should be expected that the trade between two developing countries would be largely concentrated in some specific goods*". On the other hand, the share of industrialized goods in the trade among developed countries is high.

There are a small number of papers in the literature dealing with the idea of interregional trade within a single economy. We can highlight Thompson (1965), Okazaki (1989) and Hewings *et al* (1998). Thompson's (1965) idea of evolutionary development of urban areas is based on the fact that the internal structure of the economy modifies as the process of growth and development occurs. Hence, the author examines the way development process can be followed by an increase in the intensity of interactions among sectors. The author's hypothesis is that while a region grows, there will be an increase in production intermediation. In other words, greater interaction can represent an in-filling process that happens in the structure of interdependence among sectors in a specific economy. The process of interaction can happen through the establishment of direct links among sectors for which there were no previous links or through the increase in the volume of trade among sector that had previous linkages. Thus, as the national economy matures, Thompson's (1965) development path would witness the growth of intraregional flows a greater rate than interregional transactions. In addition, it is probable that the interregional flows will be essentially interindustry flows.

Okazaki (1989) proposed another development stage, namely hollowing out. The author studied the interactions among sectors within the Japanese economy and verified that the degree of interaction had begun to fall. As affirmed before, this process was classified as hollowing out effect. Okazaki (1989) showed evidence that the degree of dependence among local sales and purchases is decreasing within the Japanese economy. According to the author, this process can be explained by the competition from South Korea, China and Indonesia. The idea here is that local (Japanese) suppliers are replaced by less expensive inputs from other international markets. It is also important to highlight that the hollowing out effect occurs in a mature economy.

Hewings *et al* (1998) put together Thompson's and Okazaki's ideas and concluded that during the process of development of an economy, it is possible to observe a process of increasing complexity in the linkages among the industrial sectors. According to the authors this process can be explained by: a) increase in per capita income that generates demand for a wide range of goods and as a consequence may increase the number of goods produced; b) increase in the size of the national market that generate opportunities to introduce new suppliers of intermediate goods. As a consequence, there is an increase in the degree of intra-national intermediation. The whole process can be represented by a logistic curve with a slow period of linkage development followed by relatively rapid deepening and extension of the linkage space. Eventually, however, the hollowing out process may occur, especially in response to cheaper transportation costs making it possible for local firms to source materials outside the region and to serve markets in other parts of the country. Therefore, we can infer that the volume of trade between poor regions or in early stage of development tend to be small. As the degree of development increase there is also an increase in trade within the region and as a consequence there will be an improvement in the interdependence within the region. On the other hand, in those regions that present a higher degree of development, we can expect that the hollowing-out process occur. At the same time, the new trade theory would indicate a high volume of intraindustry trade among the mature economies based on an intense flow of similar industrialized goods.

4. Empirical Results for the Brazilian economy

The empirical results of the extraction method for the Brazilian economy are based on the 1996 interregional input-output table for the 27 Brazilian states[18]. For the present purpose, the Brazilian table was aggregated into 8 sectors. The sectoral classification is as follows: 1 – Agriculture, 2 – Industry, 3 – S.I.U.P, 4 – Construction, 5 – Trade, 6 – Financial services, 7 – Public sector and 8 – Other services[19].

4.1 A brief characterization of the Brazilian economy

Table 1 shows the distribution of GDP by macro region and for some selected states. The result enables us to have a brief characterization of the Brazilian economy. We can highlight that there is a huge spatial concentration of development at the Southeast region. The pattern of spatial concentration did not change during the period of analysis. We can highlight that the North, South and Center-west increased their share, but the increment was not strong enough to change the

[18] The complete list of Brazilian states and regions is presented in the appendix.
[19] For more details about the matrix see Haddad *et al* (2002).

pattern of concentration at the Southeast region. This region is still responsible for more than 55% of Brazilian GDP. The increment in the Center-west share is due to the expansion of agriculture sector, mainly the exports of soybeans.

Despite the relatively desconcentration in the industrial production at São Paulo and Rio de Janeiro city we can observe that there is a tendency of spatial reconcentration in the macro-region Southeast and South (Diniz (1993) and Diniz and Crocco (1996)). This tendency can be corroborated by the development of the second level metropolis and the medium size cities. They represent areas with high probability to have economic and industrial growth. As a consequence, there could be an increase in the income and in the production and thus an improvement in the interactions (trade).

Domingues *et al*. (2002) have studied a interstate trade model which focuses attention on interactions between states in Brazil. The motivation of this paper was to explore the changes in the structure of interregional trade in the Brazilian economy between 1985 and 1997. Such exploratory analysis was carried out by means of a gravity type model and some matrix methods.
The paper highlighted the changing composition of intra regional and interregional demand, and also showed that supply and purchases state profiles have both changed, and these changes were more important in a specific group of states (Southeast).

Table 1: Share of Brazilian macro regions and selected states in the Brazilian GDP

	1985	*1990*	*1995*	*2000*
North	**3.8**	**4.9**	**4.6**	**4.6**
AM	1.5	1.8	1.7	1.7
PA	1.5	2.1	1.9	1.7
Northeast	**14.1**	**12.9**	**12.8**	**13.1**
BA	5.4	4.5	4.1	4.4
CE	1.7	1.6	1.9	1.9
PE	2.6	2.7	2.7	2.6
Southeast	**60.2**	**58.8**	**58.7**	**57.8**
MG	9.6	9.3	9.7	9.6
RJ	12.7	10.9	11.5	12.5
SP	36.1	37.0	35.5	33.7
South	**17.1**	**18.2**	**17.9**	**17.6**
PR	5.9	6.3	5.9	6.0
SC	3.3	3.7	3.6	3.9
RS	7.9	8.1	8.3	7.7
Center-west	**4.8**	**5.2**	**6.0**	**7.0**
Brazil	*100.0*	*100.0*	*100.0*	*100.0*

Source: IBGE (2004)

4.2 Backward Effects: analysis based on the buying region side

The results presented in this section are based on the equations 8b and 9. The equations generate both the interdependence between region 1 and the other regions ($x^R - \bar{x}^R$) and the backward dependence of the rest of the economy on the region 1 ($x^1 - \bar{x}^1$).

The application of the extraction method enables us to construct a typology of the Brazilian macro regions in terms of the degree of interdependence within and outside the macro region. First, we will represent the results as maps of standard deviation from the mean among states in each region. The analysis in this paper showed a significant difference in the level of spatial interaction within the five regions considered.

We can divide the Brazilian macro regions in two groups in terms of backward effects. The North, Northeast and Center-west regions form group one (Figure 1). This group is characterized by: a) a small degree of internal interactions, which means that macro regional interdependence is very small. This can be represented by the ellipses. For Figure 1A and 1C we can see that when one of the states located at region North and Center-west are isolated the impact within the region is below the mean for all the states; b) a high degree of dependence towards the Southeast region in terms of acquisition of goods; and c) there is a weak integration within the group. In other words the flows among North, Northeast and Center-west is still incipient (less than 4%). Those results corroborate the discussion presented at the literature that pointed out that trade among poor regions or in early stage of development tend to be small.

Magalhães *et al* (2000) corroborate the findings for Northeast region. The authors implemented Dendrinos-Sonis model and concluded that, in general terms, there is a weak degree of interaction within the Northeast region.

The second group is formed by the Southeast and South region. The main points are: a) there is a high degree of intra-regional interdependence, which means that there is a high impact in the product of the states located at the region when one of the other states located at Southeast or South are isolated; and b) the dependence upon the other Brazilian macro regions is incipient.

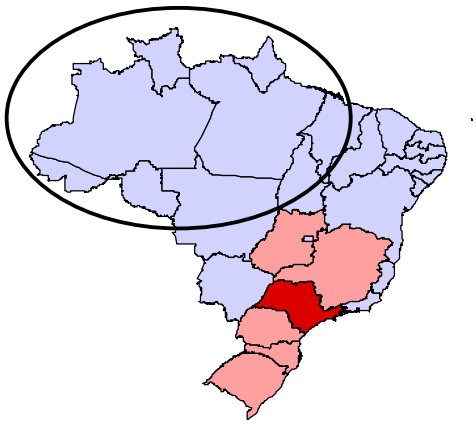
The high degree of intra-regional interdependence presented by the states located at Southeast and South also corroborates the discussion presented in the literature that points out that regions with high degree of development tend to present a high degree of trade within the region. As a consequence, there will be an improvement in the interdependence within the region. We can observe this pattern at Figure 2.

Thus, we can affirm that the pattern of spatial interaction presented by regions Southeast and South (e.g high level of interconnection within the regions) can be related to the level of development of those regions (e.g higher levels of development could be related to higher volume of trade, mainly intra-industry trade).

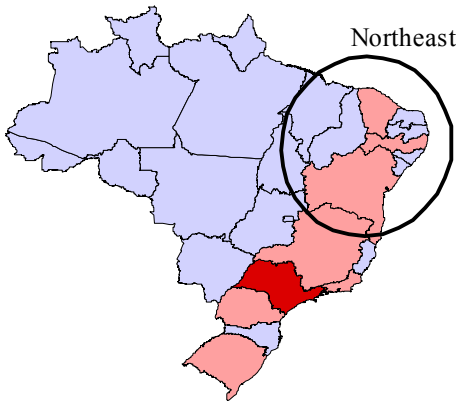
Figure 1. Backward Effects – standard deviations

(North, Northeast and Center-west)

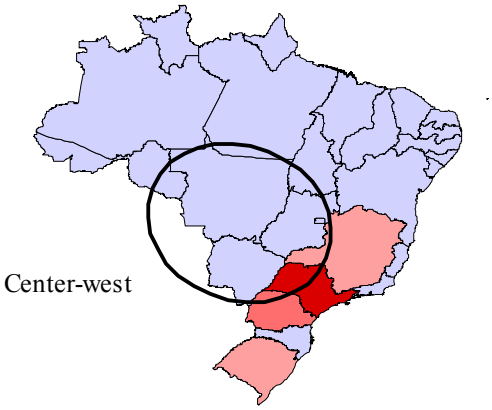
North - Standard deviation (A)



Northeast - Standard deviation (B)



Center-west - Standard deviation (C)



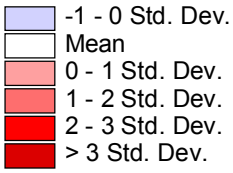
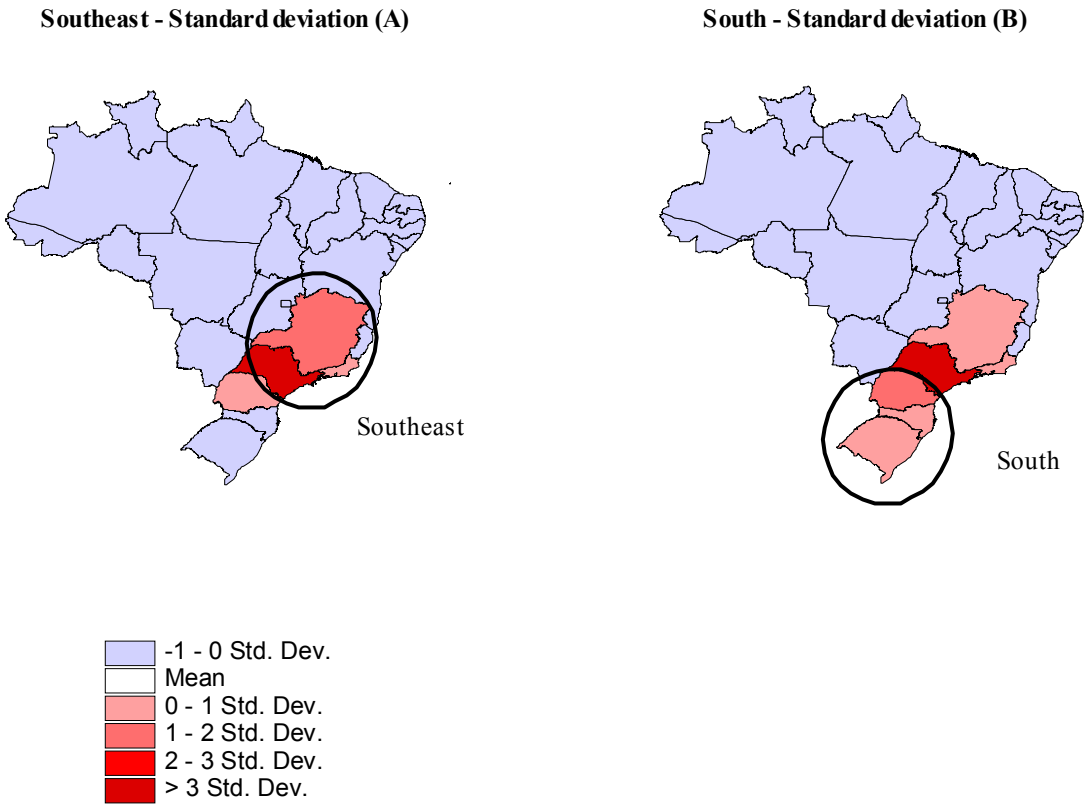


Figure 2. Backward Effects – standard deviations

(Southeast and South)



Another interesting result about the Brazilian states interconnection is taken from the comparison between *BL* (backward effects) and IF_b (backward inter-state feedbacks) (Table 1). Backward results were calculated based on equation (8b). The vector $x^R - \bar{x}^R$ measures the dependence of region 1 upon the regions in R (rest of Brazil) with regard to the purchasing of inputs. On the other hand, vector $x^1 - \bar{x}^1$ represents the backward dependence of the regions in *R* upon region 1 (hypothetically isolated). The value of *BL* is obtained by summing all off-diagonal elements in each column. IF_b represents the backward dependence of the rest of Brazil upon region 1, which means backward interstate feedbacks.

According to the results it is possible to conclude that the backward dependence of each isolated state upon the rest of the Brazilian economy is more important than the backward dependence of the rest of the Brazilian economy upon the isolated state for every Brazilian state, but São Paulo. *(BL* >

IF_b). The results presented at Table 1 also enables us to conclude that for the states located at North, Northeast, Center-west and for Espirito Santo state the backward dependence upon the rest of the Brazilian economy is much more important than to the others states. For those states *BL* is greater than 10.00. This result enables us to infer that the economy of those states (regions) is strongly oriented towards other parts of the country, especially the Southeast (São Paulo, Rio de Janeiro and Minas Gerais) and South (Paraná, Santa Catarina and Rio Grande do Sul).

Table 1. Backward versus Backward inter-state feedbacks

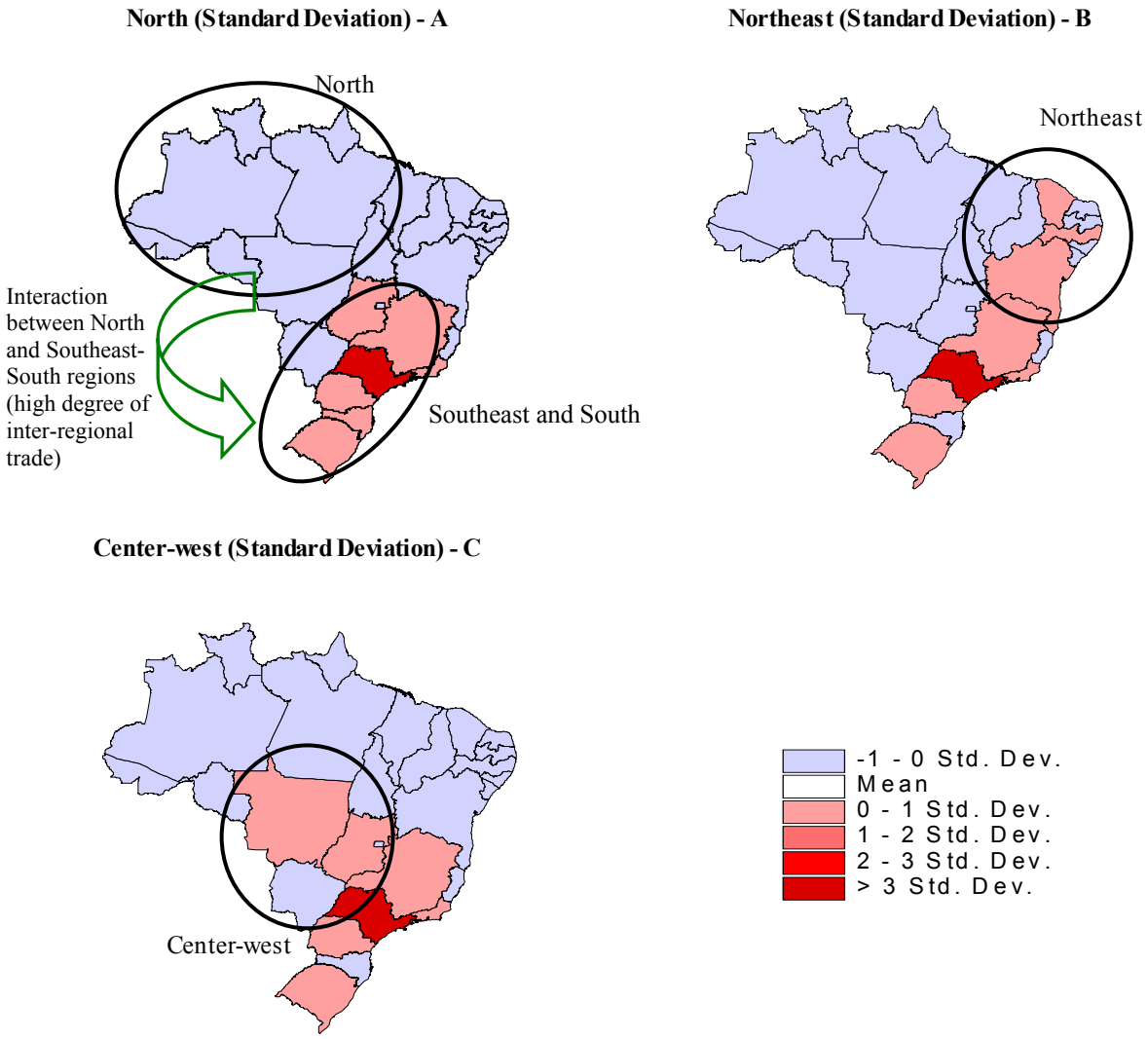
	State	*BL*	*IFb*
Isolated State	**North**	**24.127**	**0.031**
	Acre (AC)	30.265	0.003
	Amazonas (AM)	20.321	0.154
	Amapá (AP)	19.629	0.001
	Para (PA)	21.007	0.042
	Rondônia (RO)	20.853	0.012
	Roraima (RR)	29.468	0.001
	Tocantins (TO)	27.343	0.007
	Northeast	**24.873**	**0.090**
	Alagoas (AL)	34.680	0.049
	Bahia (BA)	24.632	0.232
	Ceará (CE)	22.735	0.130
	Maranhão (MA)	27.502	0.024
	Paraíba (PB)	23.312	0.050
	Pernambuco (PE)	22.392	0.223
	Piauí (PI)	20.550	0.013
	Rio Grande do Norte (RN)	26.930	0.040
	Sergipe (SE)	21.126	0.050
	Southeast	**5.902**	**2.261**
	Espírito Santo (ES)	12.024	0.236
	Minas Gerais (MG)	5.444	1.305
	Rio de Janeiro (RJ)	3.977	0.630
	São Paulo (SP)	2.164	6.874
	South	**6.821**	**0.590**
	Paraná (PR)	9.779	0.780
	Santa Catarina (SC)	6.249	0.456
	Rio Grande do Sul (RS)	4.434	0.533
	Center-west	**30.806**	**0.110**
	Distrito Federal (DF)	37.874	0.021
	Goiás (GO)	14.505	0.233
	Mato Grosso (MT)	43.916	0.122
	Mato Grosso do Sul (MS)	26.927	0.065

Source: Based on the model results

4.3 Forward Effects: an analysis based on the idea of selling region

Forward results were calculated based on equation (14). The vector $x^R - \bar{x}^R$ measures the dependence of region 1 upon the regions in R (rest of Brazil) with regard to the sale of its output. On the other hand, vector $x^1 - \bar{x}^1$ represents the forward dependence of the regions in *R* upon region 1 (hypothetically isolated). The value of *FL* (forward effect) is obtained by summing all off-diagonal elements in each column. IF_f represents the forward dependence of the rest of Brazil upon region 1, which means forward interstate feedbacks.

Figure 3 Forward Effects: Standard deviations
(North, Northeast and Center-west)



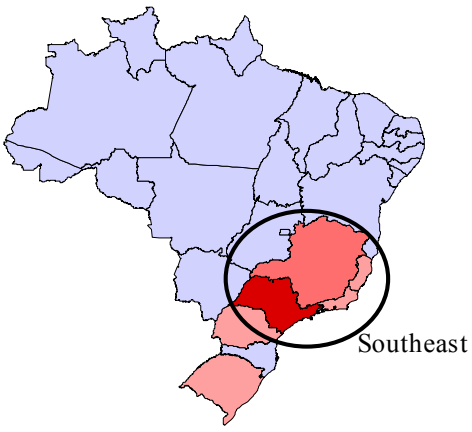
The forward effects results can be taking as a proxy of the amount of products sold by the states that are being examined. Thus, as Figure 3A shows we can affirm that the principal destination of the production at North is the Southeast and South region (above 55% - warm colors and the direction of trade is represented by the arrow). In other words, great part of the goods produced at the North region is consumed at Southeast and South. The analysis of Figure 3A also enables us to affirm that there is a weak interaction within the macro-region (below 3% - represented by blue). Thus, the interregional flows are greater than intra-regional flows.

We can affirm that the same pattern occurs to the Northeast and Center-west, but with a small difference. As we can observe at Figure 3B and 3C the most important market to the production of those regions is also the Southeast, except Espirito Santo state and South region, except Santa Catarina state. Despite the importance of Southeast and South we can also highlight the role played by Pernambuco, Ceará and Bahia state as market for the production of Northeast (Figure 3B) and by Mato Grosso and Goias state as market for the production of Center-west (Figure 3C). Thus examining the linkages by the selling region we can affirm that North region does not present a high degree of intra-interdependence and Northeast and Center-west present, for those states pointed earlier, a degree of intra-regional interdependence above the mean.

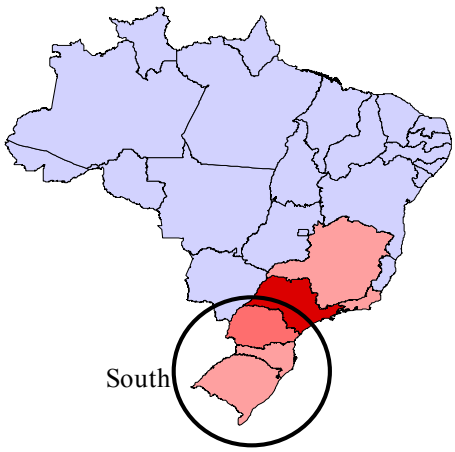
Figure 4. Forward Effects: Standard deviations

(Southeast and South)

Southeast (Standard Deviation) - D



South (Standard Deviation) - E



The pattern presented by the interdependence, in terms of the selling region, for Southeast and South can be summarized as follows: a) Those regions presents a high degree of intra-regional

interdependence (see ellipses in Figure 4D and 4E). The trade among the states located both at Southeast and South are above the mean, which means that the most important market for the products from those regions is the regional market; and b) The inter-regional interdependence when compared with the intra-regional one is less intense. We can observe at Figure 4D and 4E that the interaction with the rest of Brazil is below the mean (*e.g* cold colors).

5. Conclusions

The motivation of this paper was to explore the relationship among the Brazilian regions. As we saw, there are a great number of methodologies that can be used to analyze the interdependencies between sectors and regions. In this paper, such analysis was carried out by means of the hypothetical extraction method. The results of the methodology applied for 1996 Brazilian interregional input-output table enables us to conclude that the economic growth of the North, Northeast and Center-west, in terms of backward effects, is more dependent on the performance of the rest of the national economy, mainly Southeast and South, than on the own economy.

Based on the analysis of the backward and forward effects we can point the importance of São Paulo state in the national context, in other words we can see that the majority of Brazilian states have a strong relationship with São Paulo state. In other words, the growth of the other Brazilian states is influenced in a high level by the growth of São Paulo.

The methodology enables us to construct a hierarchy, in terms of backward and forward dependence, of the Brazilian states. As we can see the states with the higher degree of independence are located at the Southeast and South of Brazil.

The result also enables us to compare the degree of dependence among the states within the macro region. In this respect, we can observe that both in terms of backward and in terms of forward linkages the South and Southeast (*i.e* regions that have the highest share in the Brazilian GDP) presents a high degree of dependence within the region (*i.e* a higher degree of intra-regional interaction). It is interesting to highlight that this kind of results corroborates the idea developed by Thompson (1965) and Hewings (1998).

On the other hand, the states located at North, Northeast and Center-west (the regions with lower level of income) presents a low degree of dependence within the macro region. Based on these results we could affirm that an increase in final demand in the North and Northeast would induce

effects in a higher degree at Southeast region than within the region. This kind of result is very important for the policymaker if they want to implement policies designed to reduce disparities across regions. For instance, the regional policies should be implemented in such way to explore as much as possible the existent structure of economic interactions.

A further step in the study of interactions among the Brazilian states can be realized through the implementation of the methodology also in the sectoral level. Hence, we will measure the linkages among the states and sectors.

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APPENDIX

Brazilian Macro regions and States

Macro region	*State*
North (N)	Acre (AC)
	Amazonas (AM)
	Amapá (AP)
	Para (PA)
	Rondônia (RO)
	Roraima (RR)
	Tocantins (TO)
Northeast (NE)	Alagoas (AL)
	Bahia (BA)
	Ceará (CE)
	Maranhão (MA)
	Paraíba (PB)
	Pernambuco (PE)
	Piauí (PI)
	Rio Grande do Norte (RN)
	Sergipe (SE)
Southeast (SE)	Espírito Santo (ES)
	Minas Gerais (MG)
	Rio de Janeiro (RJ)
	São Paulo (SP)
South (S)	Paraná (PR)
	Santa Catarina (SC)
	Rio Grande do Sul (RS)
Center-west (CW)	Distrito Federal (DF)
	Goiás (GO)
	Mato Grosso (MT)
	Mato Grosso do Sul (MS)

BRAZILLIAN STATES AND SOUTH AMERICAN COUNTRIES

The states are: Acre (AC), Amapá (AP), Amazonas (AM), Pará (PA), Rondônia (RO), Roraima (RR), Tocantins (TO), Alagoas (AL), Bahia (BA), Ceará (CE), Maranhão (MA), Paraíba (PB), Pernambuco (PE), Piauí (PI), Rio Grande do Norte (RN), Sergipe (SE), Espírito Santo (ES), Minas Gerais (MG), Rio de Janeiro (RJ), São Paulo (SP), Paraná (PR), Santa Catarina (SC), Rio Grande do Sul (RS), Distrito Federal (DF), Goiás (GO), Mato Grosso (MT) and Mato Grosso do Sul (MS).