

# **Estimation of Interregional Systems, is the Method Important? Comparing Brazil's SUIT and IIOAS Approaches**

**Carlos Alberto Gonçalves Junior**

*Department of Economics, FEA - University of São Paulo  
E-mail: carlosalbertojr@usp.com*

**Joaquim José Martins Guilhoto**

*OECD Directorate for Science, Technology and Innovation and University of São Paulo  
E-mail: joaquim.guilhoto@oecd.org*

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## **ABSTRACT**

Due to the lack of information, the construction of interregional input-output systems is usually carried out in a hybrid way, combining information obtained from survey with non-survey techniques. The diversity of non-survey techniques and the different ways of combining them may lead to the estimation of different interregional input-output systems for the same set of regions. In view of the above, the objective of this paper is to identify how the choice between different methods to estimate interregional systems may influence the results and policy analysis based on them. Therefore, the present paper describes in details two different methodologies developed to estimate an interregional system for the 27 states of the Brazilian economy, SUIT (Guilhoto et al, 2017) and IIOAS (Haddad et al 2017); subsequently, the interregional systems estimated from IIOAS and SUIT are compared in order to identify the main differences existing in holistic and partitive terms. The results show that, despite significant differences, mainly in partitive terms, in general the choice between the two methods does not compromise the overall results of the input-output analysis. However, for specific studies that involve a particular industry or region the analyst must be aware that possible differences may arise, as they are pointed out in the paper.

## 1. Introduction

Much has been advanced since the first incursions of Isard (1951) and Leontief et al. (1953) in regional and interregional extensions of input-output models. However, from the outset, the scarcity of information, as well as the high cost to obtain them through surveys, especially interregional trade flows, have been the main obstacles in estimation of interregional input-output systems. Then, non-surveys estimation methods gained a lot of academic popularity (ROUND, 1983).

The construction of regional and interregional input-output systems is the subject of researchers around the world. Some recent experiences include: (i) Zhang, Shi and Zhao (2015), who built an interregional input-output system for 30 Chinese provinces; (ii) Tobben and Kronenberg (2015), who developed an update of the CHARM (Cross-hauling adjusted regionalization Method) for more than two regions; and (iii) Haddad et al. (2016), who built an interregional input-output system for 33 Colombian regions. All of them, under conditions of limited information.

Regarding Brazil, several efforts have been made. These include: (i) Guilhoto et al. (2010) that constructed an interregional input-output system for Brazilian Northeast states; (ii) Domingues and Haddad (2002) developed an interregional system for Minas Gerais state and the rest of Brazil; (iii) Porsse, Haddad and Pontual (2003) estimated an interregional matrix for Rio Grande do Sul state and the rest of Brazil; (iv) Ichihara and Guilhoto (2008) estimated an inter-municipal input-output system for São Paulo state municipalities; and (v) Guilhoto and Sesso Filho (2005b) constructed an interregional system for the 9 states of activity of Amazônia's Bank and the rest of Brazil for 1999.

The aforementioned papers are estimates of municipal interregional systems or estimates for only a part of the Brazilian states. When it comes to the construction of an interregional system for all Brazilian states under conditions of limited information, the initiatives are scarce, namely: Haddad, Gonçalves Jr and Nascimento (2017) who used the Interregional Input-Output Adjustment System (IIOAS) method to estimate an interregional input-output system for the 27 Brazilian UFs with 68 sectors and 128 products and Guilhoto et al. (2017) who estimated an interregional input-output system, also for the 27 Brazilian Federal Units (UFs), with 68 sectors and 128 products, using the Supply and Uses Interregional Tables (SUIT) method.

In this context, this paper aims to identify the differences between the interregional input-output systems, built for the 27 Brazilian UFs, using the SUIT and IIOAS methods. These differences will be measured in partitive and holistic terms. In this way, it will be verified if subnational systems constructed for the same year and the same set of regions, using these two mentioned methods, generate divergent results in the input-output analysis.

In order to reach this aim, apart from this introduction, this paper is divided into four sections. In the second section the estimation methods of interregional input-output systems SUIT and IIOAS are described. The third section presents the techniques used in the comparison between the interregional systems, estimated from SUIT and IIOAS. The results are presented in the fourth section, and the fifth section brings the final remarks.

## 2. SUIT and IIOAS Methods

In Brazil, as in other countries of the world, the scarcity of information to build an input-output interstate system is evident. Thus, data from the Regional Accounts and from surveys conducted by the Brazilian Institute of Geography and Statistics (IBGE) to the non-survey estimation techniques are combined to build interregional input-output systems.

In this sense, this section, based on Guilhoto et al. (2017) and Haddad, Gonçalves Junior and Nascimento (2017), is dedicated to the presentation of SUIT and IIOAS methods. These methods are developed by combining top-down and bottom-up approaches. In this way, subnational information, used to capture peculiarities of each state, is combined with the information contained in the national Use, Supply, Imports and Taxes tables, guaranteeing the consistency of the estimated systems with the National Accounts. In addition, SUIT and IIOAS methods use hybrid techniques, combining survey data and estimated data in order to build the interregional system for the 27 UFs.

Both methods were applied in the construction of an interregional input-output system for the 27 UFs, based on the national input-output system for 2011, disaggregated in 68 sectors of activity and 128 products. The national input-output system is composed by (i) Supply table; (ii) Use table; (iii) Imports table; and (iv) Taxes table. These tables were obtained by applying the method presented by Guilhoto and Sesso Filho (2005a) and Guilhoto and Sesso Filho (2010).

The databases used in the process of disaggregation of the national matrices come from the Regional Accounts and official surveys, carried out by IBGE. This information is common to SUIT and IIOAS. This ensures that the differences between the two interregional input-output systems estimated are only derived from the specificities of each method.

### 2.1. Supply and Uses Interregional Tables - SUIT

The estimation process starts with the Regional Supply Tables. The National Supply Table informs what each sector of the economy produces of each product in the country. The first step for the construction of the Supply Tables for each UF is the estimation of Regional Gross Output for the 68 sectors and 128 products, using the Regional Accounts and the official surveys published by IBGE.

Initially, the Regional Supply Tables maintain the same structure of the national Supply Table. To this end, the National Coefficients  $CP_{sxp}^N$  are constructed, according to the Equation:

$$CP_{sxp}^N = MP_{sxp}^N * inv(diag(\sum_{s=1}^{68} mp_{sp})) \quad \forall s = 1, \dots, 68 \text{ e } p = 1, \dots, 128; \quad (1)$$

Where  $s$  are the sectors;  $p$  the products;  $MP_{sxp}^N$  is the National Supply Table;  $mp_{sp}$  is each element of the National Supply Table. Then, the Regional Gross Output of each sector in each UF are multiplied by  $CP_{sxp}^N$  and we have the first estimate of the Regional Supply Matrices  $MP_{sxp}^{UF}$ , according to the Equation:

$$MP_{sxp}^{UF} = diag(VBP_s^{UF}) * CP_{sxp}^N \quad \forall s = 1, \dots, 68 \text{ e } p = 1, \dots, 128; \quad (2)$$

Where,  $VBP_s^{UF}$  is the sectoral Gross Output of each UF. Subsequently, the iterative RAS procedure is used to ensure consistency of the Regional Supply Tables with the Regional Accounts and the National Supply Table. This procedure alters the initial assumption that regional production structures are the same as the national structure.

The next step is the construction of the Use Tables (product x sector) for the 27 UFs. The Use Tables record the quantity of products that each sector uses as input to carry out its production.

The Regional Gross Output, by product and by sector, were already estimated in the Regional Supply Tables. The share of each state in national imports is obtained from

the Foreign Trade Information System - AliceWeb. If there is no information about some product or service, this Equation is used:

$$m_p^{UF} = m_p^N \frac{z_p^{UF} + d_p^{UF}}{z_p^N + d_p^N} \quad (3)$$

Where  $m_p^{UF}$  is the import of the product  $p$  by the UF;  $m_p^N$  is the national import of the product  $p$ ;  $z_p^{UF}$  is the intermediate demand of the product  $p$  in the UF;  $z_p^N$  is the national intermediate demand of the product  $p$ ;  $d_p^{UF}$  is the final demand of the product  $p$  in the UF and  $d_p^N$  is the national final demand of the product  $p$ .

By AliceWeb system we know which products are being imported by each UF, however, we can't know which sectors of the respective UFs are importing, nor whether this import is for Intermediate Consumption or Final Demand. To solve this problem, it is initially assumed that the use of imports by all UFs follows the national structure, both for Intermediate Consumption and for Final Demand. For this, the National Imports Coefficients  $Cimp_{ij}^N$  are constructed using the National Imports Table:

$$Cimp_{pxs}^N = inv(diag(\sum_{s=1}^{68} mimp_{ps}^N)) * Mimp_{pxs}^N \quad (4)$$

Where  $Mimp_{pxs}^N$  is the National Imports Table and  $mimp_{ps}$  is each element of this Table. The national imports coefficients are then multiplied by the imports by product of each UF  $imp_{pxl}^{UF}$ :

$$Mimp_{pxs}^{UF} = diag(imp_{pxl}^{UF}) * Cimp_{pxs}^N \quad (5)$$

In this way, 27 Regional Imports Tables are obtained. Subsequently, the Regional Imports Tables are adjusted by the procedure RAS, ensuring that: (i) the national share of each UF in imports of each product is maintained; and (ii) the sum of the imports of each sector in each UF is the same as the national imports of each sector. Next, the sectoral imports vector by UF is obtained by multiplying:

$$Vimp_{1xs}^{UF} = e'_{1xp} * Mimp_{1xs}^{UF} \quad (6)$$

Where  $Vimp_{1xs}^{UF}$  is the sectoral import vector for each UF and  $e'_{1xp}$  is a row vector of ones. The Value Added elements (by UF and by sector) named: (i) Wages; (ii) Gross Operating Surplus (EOB) are estimated based on the Regional Accounts and official surveys such as the National Household Sample Survey - PNAD and the Annual Social Information Report - RAIS.

Net Indirect Taxes (IIL) are obtained for each UF based on data from: Internal Revenue Service, National Treasury, Social Security and Caixa Econômica Federal. Subsequently, to desegregate these data into 68 sectors, we used the same proportions between Gross Output and Net Indirect Taxes in the national Use Table.

Thus, according to the described procedures we have: (i) Regional Gross Output; (ii) Value Added elements; (iii) imports from the rest of the world; and (iv) Net Indirect Taxes for each UF. Therefore, the following conditions must be met: (i) The national Gross Output must be equal to the sum of the Regional Gross Outputs; (ii) Imports + IIL + VA = GDP from the income approach; (iii) VBP - Imports - IIL - VA =  $\Sigma$ CI, i.e., the sum of Intermediate Consumption of all sectors.

The Final Demand is composed by five elements, namely: (i) Exports; (ii) Household Consumption; (iii) Consumption of Non-Profit Institutions; (iv) Investments; and (v) Government Expenditures.

Exports by products are obtained from AliceWeb. For products and services whose data are not available on AliceWeb, the following equation is used:

$$e_p^{UF} = e_p^N \frac{x_p^{UF}}{x_p^N} \quad (7)$$

Where  $e_p^{UF}$  are regional exports of the product  $p$ ;  $e_p^N$  the national exports of the product  $p$ ;  $x_p^{UF}$  and  $x_p^N$  are respectively gross regional and national output. Household Consumption, by UF and by product, is obtained using Family Budget Survey - POF.

The Regional Consumption of Non-Profit Institutions is calculated by a simple average between the participation of each UF in the Gross Output of the following sectors: (i) Art, culture, sports and recreation and other service activities (from Regional Accounts); (ii) and Associative Organizations and Other Personal Services (from the Regional Supply Tables).

The Investment (by product and by UF) follows the procedure: (i) a simple average is made between the share of Regional Gross Output of the Civil Construction sector in the national Gross Output of Civil Construction sector, and the share of Regional Gross Operating Surplus in the national Gross Operating Surplus, in order to obtain the total Investment for each UF from national Investment; (ii) then the total Investment per UF is distributed among the UFs sectors using the structure of the regional Gross Operating Surplus vector; (iii) it is necessary to disaggregate the Investment of each sector in each UF into 128 products, to do so, we used the matrix of investment absorption, according to Miguez et al. (2017).

$$CMinv_{pxs}^N = Minv_{pxs}^N * inv(diag(\sum_{p=1}^{128} invest_{ps})) \quad (8)$$

$$FBCF_{pxs}^{UF} = CMinv_{pxs}^N * diag(fbck_{1xs}^{UF}) \quad (9)$$

$$fbcf_{1xp}^{UF} = FBCF_{pxs}^{UF} * e'_{sxl} \quad (10)$$

Where,  $Minv_{pxs}^N$  is the investment absorption matrix; and  $invest_{ps}$  is each element of this investment absorption matrix,  $fbck_{1xs}^{UF}$  is Investment the vector by sector for each UF, and  $fbcf_{1xp}^{UF}$  is the Investment vector by product that will be inserted in the Regional Use Table of each UF. A RAS procedure is then used to ensure consistency with national tables.

Government Expenditures (by sector, by UF) are estimated based on the participation of each UF in the GDP of the public administration, published by IBGE in the Regional Accounts.

The next element of the Regional Use Tables to be estimated is Intermediate Consumption - CI (product x sector). First, intraregional flows are calculated using Cross Industries Locational Quotient-CIQ.

$$CIQ_{ps}^{UF,UF} = \left( \frac{x_p^{UF} / x_p^N}{x_s^{UF} / x_s^N} \right) \quad (11)$$

Where  $x_p^{UF}$  and  $x_p^N$  are the regional and national Gross Output by product,;  $x_s^{UF}$  and  $x_s^N$  are the regional and national Gross Output by sector.

The adjustment of the national coefficient to regional coefficient is not the same for all products, because it is necessary to consider the potential trade of each product, according to the Equation:

$$a_{ps}^{UF,UF} = \begin{cases} (CIQ_{ps}^{UF}).(a_{ps}^N)...se...(CIQ_{ps}^{UF} < X) \\ a_{ps}^N.X.....se...(CIQ_{ps}^{UF} \geq X) \end{cases} \quad (12)$$

For the sectors related to (i) Agriculture, (ii) Mineral Extraction and (iii) Manufacturing, we use  $X = 0.95$ . For the sectors of (i) Public Administration, (ii) Associative Organizations and Personal Services; (iii) Domestic Services, it is used  $X = 1$ . For the other sectors,  $X = 0.9$ .

After the estimation of the intraregional coefficients for the 27 UFs ( $A^{UF,UF}$ ), the interregional flows are calculated. Initially, we estimate the matrices of technical coefficients corresponding to the flows of each UF with the rest of the UFs (RUFs), according to the Equation:

$$A^N - A^{UF,UF} = A^{RUF,UF} \quad (13)$$

Where  $A^N$  is the national matrix of technical coefficients;  $A^{UF,UF}$  is the matrix of intraregional technical coefficients for each UF; and  $A^{RUF,UF}$  is the interregional coefficient matrix, which shows the trade coefficients of the remaining UFs with each UF.

The next step will be to disaggregate each  $A^{RUF,UF}$  in other 26 matrices, one for each origin UF , using the Equation:

$$Partic_p^{UFO \rightarrow UFD} = \frac{X_p^{UFO}}{X_p^N - X_p^{UFD}} \quad (14)$$

Where  $Partic_p^{UFO \rightarrow UFD}$  is the share of the origin UF in purchases of the destination UF;  $X_p^{UFO}$  is the gross output of product  $p$  in origin UF;  $X_p^{UFD}$  is the total output of product  $p$  in the destination UF;  $X_p^N$  is the national gross output of product  $p$ .

Once the interregional matrix is obtained for each UF, they are normalized by the column, so that the sum of each column will be equal to one. The flows in monetary values are obtained by multiplying these matrices by the sectoral intermediate consumption of each UF, according to the Equation:

$$CII_{pxs}^{UF} = CICI_{pxs}^{UF} * diag(CIT_{1xs}^{UF}) \quad (15)$$

Where,  $CII_{pxs}^{UF}$  is the monetary values of interregional intermediate consumption in each UF;  $CICI_{pxs}^{UF}$  is the interregional coefficient of intermediate consumption for each UF;  $CIT_{1xs}^{UF}$  is a vector of sectoral intermediate consumption in each UF, where the last one is calculated according to the equation:

$$CIT_{1xs}^{UF} = VBP_{1xs}^{UF} - VA_{1xs}^{UF} - ILL_{1xs}^{UF} - import_{1xs}^{UF} \quad (16)$$

Where  $VBP_{1xs}^{UF}$  is the sectoral Gross Output in each UF;  $VA_{1xs}^{UF}$  is the sectoral Value Added in each UF;  $ILL_{1xs}^{UF}$  are the sectoral Net Indirect Taxes; and  $import_{1xs}^{UF}$  are the sectoral Imports in each UF, all of them previously estimated.

With regard to the intra and interregional flows of the Final Demand, we assume the hypothesis that there are only flows for Household Consumption and for Investment. The Simple Locational Quotient method is used to estimate the intraregional and interregional flows of these Final Demand elements, using the same criteria as of the intermediate consumption.

Finally, inventories are obtained residually. However, some adjustments are made: (i) if in the national matrix the inventory in a sector is zero, in the estimated interregional matrix the inventory in this sector should be zero for all states. In this case, the differences must be redistributed along the line of Intermediate Consumption and Final Demand; (ii) differences are tolerated between the inventories of the national matrix and each UF matrix up to 20%. Larger differences are distributed to other sectors.

Thus, after the estimation of all Regional Supply Tables (sector x product) and all Regional and Interregional Use Tables (product x sector), the Interregional Matrix of Input-output (sector x sector) can be finally calculated.

Each element of the regional Supply Tables is divided by the sum of its respective column to build the coefficients matrices for each UF:

$$CP_{sxp}^{UF} = MP_{sxp}^{UF} * inv(diag(\sum_{p=1}^{128} mp_{sp}^{UF})) \quad (17)$$

Where  $CP_{sxp}^{UF}$  are the coefficients for UFs,  $MP_{sxp}^{UF}$  are the Supply Table of each UF and  $mp_{ij}^{UF}$  is each  $sp$  element of the Supply Table in each UF. Subsequently:

$$\begin{bmatrix} CP_{sxp}^{UF1} & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & CP_{sxp}^{UF27} \end{bmatrix} * \begin{bmatrix} U_{pxs}^{UF1,UF1} & \dots & U_{pxs}^{UF1,UF27} \\ \vdots & \ddots & \vdots \\ U_{pxs}^{UF27,UF1} & \dots & U_{pxs}^{UF27,UF27} \end{bmatrix} = \begin{bmatrix} Z_{sxs}^{UF1,UF1} & \dots & Z_{sxs}^{UF1,UF27} \\ \vdots & \ddots & \vdots \\ Z_{sxs}^{UF27,UF1} & \dots & Z_{sxs}^{UF27,UF27} \end{bmatrix} \quad (18)$$

The resulting Z matrix is the Intermediate Consumption Matrix (sector x sector). The Final Demand elements can also be multiplied by the coefficient Matrix, to obtain the Final Demand (sector x sector).

## 2.2. Interregional Input-Output Adjustment System – IIOAS

The interstate system estimated by IIOAS is built using the national Input-Output system and: (i) Gross Output (by sector and by UF)  $VBP^R$ ; (ii) Exports (by UF and by sector)  $X^R$ ; (iii) Value Added (by UF and by sector)  $VA^R$ ; (iv) Investment by UF  $INVT^R$ ; (v) Household Consumption by UF  $CFT^R$ ; and (vi) Government Expenditures by UF  $GGT^R$ . These data are the same as used in SUIT.

A key step in the IIOAS construction process is the estimation of interstate trade matrices, which are built calculating by sector: (i) domestic regional demand; (ii) regional demand for imports; and (iii) domestic regional supply. To obtain domestic regional demand, the coefficients for each user are constructed from the national Use Tables (sector x sector)<sup>1</sup>:

$$CCI_{ixj}^{DOM} = Z_{ixj}^{DOM} * \hat{X}_j^{-1} \quad (19)$$

Where  $CCI_{ixj}^N$  is the national coefficient of domestic intermediate consumption,  $Z^{DOM}$  is the national matrix of domestic intermediate consumption, and  $X_j$  is the national Gross Output. The coefficients are also calculated for the final demand elements:

<sup>1</sup> In this paper, unlike SUIT, the IIOAS is built on the structure (sector x sector)

$$CINV_{ixl}^{DOM} = \frac{inv_i^{DOM}}{INVT^N}; CCF_{ixl}^{DOM} = \frac{cf_i^{DOM}}{CFT^N}; CGG_{ixl}^{DOM} = \frac{gg_i^{DOM}}{GGT^N} \quad (20)$$

Where  $inv_i^{DOM}$ ,  $cf_i^{DOM}$  and  $gg_i^{DOM}$  are, respectively, each element  $i$  of the (i) investment (ii) household consumption and (iii) government expenditures, and  $INVT^N$ ,  $CFT^N$ ,  $GGT^N$  are respectively the sum (including taxes) of these respective vectors.

The domestic demand in each UF is obtained by multiplying these coefficients by: (i) Regional Gross Output  $VBP^R$ ; (ii) Regional Investment  $INVT^R$ ; (iii) Regional Household Consumption  $CFT^R$ ; and (iv) Regional Government Expenditures  $GGT^R$ .

$$CI_{ixj}^{R,DOM} = CCI_{ixj}^{DOM} * diag(VBP_{ixl}^R) \quad \forall i, j = 1, \dots, 68 \text{ e } \forall R = 1, \dots, 27 \quad (21)$$

$$INV_{ixl}^{R,DOM} = CINV_{ixl}^{DOM} * INVT_{ixl}^R \quad \forall i = 1, \dots, 68 \text{ e } \forall R = 1, \dots, 27 \quad (22)$$

$$CF_{ixl}^{R,DOM} = CCF_{ixl}^{DOM} * CFT_{ixl}^R \quad \forall i = 1, \dots, 68 \text{ e } \forall R = 1, \dots, 27 \quad (23)$$

$$GG_{ixl}^{R,DOM} = CGG_{ixl}^{DOM} * GGT_{ixl}^R \quad \forall i = 1, \dots, 68 \text{ e } \forall R = 1, \dots, 27 \quad (24)$$

Where  $CI_{ixj}^{R,DOM}$  is the regional domestic intermediate consumption,  $INV_{ixl}^{R,DOM}$  is the regional domestic Investments,  $CF_{ixl}^{R,DOM}$  is the regional domestic household consumption, and  $GG_{ixl}^{R,DOM}$  are domestic regional government expenditures. Subsequently, total domestic demand is obtained by summing up:

$$DEMDOM_{ixl}^R = \sum_{j=1}^{68} CI_{ixj}^{R,DOM} + INV_{ixl}^{R,DOM} + CF_{ixl}^{R,DOM} + GG_{ixl}^{R,DOM} \quad \forall i = 1, \dots, 68 \\ \forall R = 1, \dots, 27 \quad (25)$$

The procedure is similar when regarding the regional demand for imports. The coefficients of demand for imported goods are constructed from the share of each element of the national Imports Table in the totals of each column of the national Uses Table, and later multiplied by the regional totals, following the same procedure of domestic demand.

The regional demand for imported goods is calculated by the sum:

$$DEMIMP_{ixl}^R = \sum_{j=1}^{68} CI_{ixj}^{R,IMP} + INV_{ixl}^{R,IMP} + CF_{ixl}^{R,IMP} + GG_{ixl}^{R,IMP} \quad \forall i = 1, \dots, 68 \\ \forall R = 1, \dots, 27 \quad (26)$$

This regionalization is consistent with the National Tables, i.e., the sum of  $DEMDOM_{ixl}^R$  for all Regions must be equal to the Gross Output of each sector in the national Use Table, without exports. In addition, the sum of  $DEMIMP_{ixl}^R$  for all Regions must be equal to the total imports by sector in the national Imports Table.

By putting the vectors of domestic demand  $DEMDOM_{ixl}^R$  side by side for all Regions, we have a matrix of dimensions  $(ixR)$  where, each row of this matrix represents the domestic demand of one sector  $i$  in each of 27 UFs -  $DEMDOM_{ixR}$ .

Regarding demand for imports, by putting each vector  $R$  side by side, we have a matrix  $(ixR)$  where each row represents the total imports of sector  $i$  by each region  $R$  -  $DEMIMP_{ixR}$ .

The next step is to estimate the domestic regional supply -  $OFDOM$ . It is obtained from the difference between Gross Output by sector in each UF  $VBP^R$  and exports by sector in each UF  $X^R$ .



$$OFDOM_{ixl}^R = VBP_{ixl}^R - X_{ixl}^R \quad \forall i = 1, \dots, 68 \text{ e } \forall R = 1, \dots, 27 \quad (27)$$

When putting each regional vector side by side, we have a matrix ( $ixR$ ) where each row represents the domestic supply of each sector  $i$  in each region  $R$ .

Subsequently, we build "Share Matrices" (SHIN), which represent the share of each UF in the national trade flows for each sector  $i$ . Considering the UF of origin  $s$ , and destination  $d$ , 68 matrices (one for each sector) of dimension (27x27) are built.

Two equations were used for the construction of these shares. Equation 28 was used to calculate the initial share value of intraregional trade, i.e., the main diagonal of trade matrices. Equation 29 was used to estimate interstate trade flows. Both equations are based on Dixon and Rimmer (2004).

$$SHIN(i, d, d) = \text{Min} \left\{ \frac{OFDOM(i, d)}{DEMDOM(i, d)}, 1 \right\} * F \quad (28)$$

Where SHIN ( $i, d, d$ ) is the intraregional share of sector  $i$  in national trade. ( $F$ ) gives the sectoral trade propensity. For sectors 1 to 36, which represent, in general terms, agricultural and industrial production,  $F = 0.5$ . For sectors 37 to 68, which basically represent services sectors,  $F = 0.95$ . The share of interstate trade flows is defined by the Equation:

$$SHIN(i, s, d) = \left\{ \frac{1}{\text{imped}(s, d)} \cdot \frac{OFDOM(i, s)}{\sum_{k=1}^{27} OFDOM(i, k)} \right\} * \left\{ \frac{1 - SHIN(i, d, d)}{\sum_{j=1, j \neq d}^{27} \left[ \frac{1}{\text{imped}(j, d)} \cdot \frac{OFDOM(i, j)}{\sum_{k=1}^{27} OFDOM(i, k)} \right]} \right\} \quad (29)$$

Where SHIN ( $i, s, d$ ) is the share of the trade flow of sector  $i$  with origin in region  $s$  and destination in region  $d$ ; the impedance is the average travel time between regions, considering all modals.

After obtaining the SHIN matrices for each sector  $i$  (with  $i = 1, \dots, 68$ ) the Trade Matrices were constructed by multiplying each SHIN ( $i, s, d$ )<sup>2</sup> by its respective value  $i$  in the matrix  $DEMDOM_{ixR}$ .

$$TRADE_i^{sd} = SHIN(i, s, d) * \text{diag}[DEMDOM_{ixR}(i, 1 : R)] \quad \forall i = 1, \dots, 68 \quad (30)$$

Where  $TRADE_i^{sd}$  are the trade matrices with origin in region  $s$  and destination in region  $d$ . Then a RAS procedure is used so that the trade matrices converge along the line with the supply, and the column with the demand of sector  $i$  for each pair of origin-destination ( $s, d$ ). Then, it is necessary to include in each  $TRADE_i^{sd}$  its respective line  $i$  of the matrix  $DEMIMP_{ixR}$  including the imports in the regions of origin  $s$ .

The Trade matrices reveal how much each Brazilian state sells to each other, and purchases from each other and abroad. However, it is not known whether the purchases in the destination states are for intermediate consumption (in this case, which sector) or final demand.

<sup>2</sup> Where for  $s = d$  use SHIN ( $i, d, d$ )

In order to solve this question, we used a hypothesis originally from multi-regional Chenery-Moses model, proposed by Chenery (1953) and Moses (1955), in which the same trade coefficient is applied for any sector or user in the destination region.

The first step in the regionalization process is to calculate from Trade Matrices a new SHIN\_N for each sector  $i$ :

$$SHIN\_N_{sxd}^i = TRADE_i^{sd} * \{inv[diag(\sum_{s=1}^{27} trade_i^{sd})]\} \quad (31)$$

Where  $trade_i^{sd}$  is each element of the trade matrices, where  $s$  represents the 28 regions of origin (27 national + foreign) and  $d$  represents regions of destination (27 national). Subsequently, the elements of National Use Table (sector x sector) are used to construct the national coefficients of intermediate consumption  $CC^N$ , investment  $CINV^N$ , household consumption  $CCF^N$  and government expenditures  $CGG^N$ . For intermediate consumption:

$$CC_{ij}^N = Z_{ij}^{DOM+IMP} * (diag CT_{1xj}^N)^{-1} \quad (32)$$

Where  $Z_{ij}^{DOM+IMP}$  is the intermediate consumption matrix, in which each element  $ij$  is the sum of the sources: domestic (of the national Uses Table) and imports (of the national Imports Table) and  $CT_j^N$  is the total intermediate consumption for each sector  $j$  calculated by:

$$CT_{1xj}^N = VBP_{1xj}^N - VA_{1xj}^N \quad (33)$$

Where  $VBP_{1xj}^N$  is the national Gross Output for each sector  $j$  and  $VA_{1xj}^N$  is the national Value Added for each sector  $j$ . Regarding final demand users, each value of each final demand vector is divided by its respective total (including imports and indirect taxes):

$$CINV_{ix1}^N = \frac{inv_i^{DOM+IMP}}{INVT^N}; CCF_{ix1}^N = \frac{cf_i^{DOM+IMP}}{CFT^N}; CGG_{ix1}^N = \frac{gg_i^{DOM+IMP}}{GGT^N} \quad (34)$$

Where  $inv_i^{DOM+IMP}$  is each value of investment vector, is  $cf_i^{DOM+IMP}$  each value of household consumption vector and  $gg_i^{DOM+IMP}$  is each value of government expenditures vector (considering domestic + imports sources), and  $INVT^N$ ,  $CFT^N$  and  $GGT^N$  are the total of the columns of these respective vectors in the national Uses Table.

After that, the regional coefficients are constructed by transforming the 68 SHIN\_N (which represent, for each sector, the share of trade flows between each pair origin-destination) into 28 SHIN\_S matrices of dimensions 68x27 (which represent, for each origin, including the imports, the share of purchases of each sector in each destination).

Each of the 28 SHIN\_S matrices represents an origin. In its rows, the 68 sectors of the economy are disposed, and in its columns the 27 regions of destination. In order to build the regional intermediate consumption coefficients - RCC, each column of each 28 SHIN\_S matrix is diagonalized and multiplied by  $CC_{ij}^N$ :

$$RCC_{ixj}^{sd} = diag(SHIN\_S(1:i;d)) * CC_{ij}^N \quad \forall d = 1, \dots, 27 \text{ e } \forall s = 1, \dots, 28 \quad (35)$$

Where  $s$  represents the 28 regions of origin and  $d$  are the 27 regions of destination. From Equation 35 we can construct 756 matrices (dimension 68x68), which represent the share of each sector in the intermediate consumption of each region of destination.

Regarding the final demand users, the procedure is similar. However, we build for each origin region  $s$ , 27 vectors  $68 \times 1$ . These vectors correspond to the share of each 27 destination regions  $d$  in the production of 68 sectors of activity.

The demand for investment is:

$$RCINV_{ixl}^{sd} = \text{diag}(SHIN\_S(1:i;d)) * CINV_{ixl}^N \quad \forall d = 1, \dots, 27 \quad \forall s = 1, \dots, 28 \quad (36)$$

For household consumption is:

$$RCCF_{ixl}^{sd} = \text{diag}(SHIN\_S(1:i;d)) * CCF_{ixl}^N \quad \forall d = 1, \dots, 27 \quad \forall s = 1, \dots, 28 \quad (37)$$

For government expenditures is:

$$RCGG_{ixl}^{sd} = \text{diag}(SHIN\_S(1:i;d)) * CGG_{ixl}^N \quad \forall d = 1, \dots, 27 \quad \forall s = 1, \dots, 28 \quad (38)$$

In order to obtain the regional indirect taxes share, paid by each user, national coefficients are constructed from the national Taxes Table. The tax coefficients are calculated for (i) intermediate consumption, (ii) investment and (ii) household consumption<sup>3</sup>. To regionalize national tax coefficients, SHIN\_S matrices are used, in the same way described for intermediate and final consumption.

So as to change regional coefficients into monetary flows between regions, it is necessary to multiply these coefficients by the regional values described at the beginning of this section.

In the interregional input-output system, two Equations are important:

$$VBP_j^R = \sum_{i=1}^{68} RC_{ixj}^{sd} + \sum_{i=1}^{68} RTC_{ixj}^{sd} + RVA_j^{sd} \quad (39)$$

$$DT_i^R = \sum_{j=1}^{68} RC_{ixj}^{sd} + RINV_i^{sd} + RFC_i^{sd} + XR_i^{sd} + RGG_i^{sd} \quad (40)$$

Where  $VBP_j^R$  is the Regional Gross Output for sector  $j$ ;  $RC_{ixj}^{sd}$  is the regional Intermediate Consumption;  $RTC_{ixj}^{sd}$  are the Indirect Taxes on intermediate consumption,  $RVA_j^{sd}$  is the regional Value Added for sector  $j$ ;  $DT_i^R$  is the Total Regional Demand for sector  $i$ ;  $RINV_i^{sd}$  are regional investments;  $RFC_i^{sd}$  is regional household consumption;  $XR_i^{sd}$  are regional exports; and  $RGG_i^{sd}$  are regional government expenditures.

The inventories are obtained by residue:

$$VE_i^R = VBP_j^R - DT_i^R \quad (41)$$

### 3. Description of Comparison Techniques

The comparison between interregional input-output systems can be made considering the concepts of partitive and holistic accuracy defined by Jensen (1980).

The partitive accuracy focuses on cell-by-cell analysis. Holistic accuracy emphasizes the "mathematical framework" of economic relations. The greater the proximity between the estimated systems, the greater the accuracy. The aim is to identify the method's behavior to evaluate the regions economic peculiarities, mainly with respect to the productive structure.

In addition to the partitive and holistic accuracies, it is interesting to analyze the mathematical similarity between estimated input-output interregional systems. According to Lipschutz (1994) a matrix B is similar to a matrix A if there exists a non-singular matrix

<sup>3</sup> For government expenditures, taxes are considered zero.

$P$  such that  $B = P^{-1}AP$ . Two matrices  $A$  and  $B$  are similar if they have: (i) the same determinant; (iii) the same eigenvalues; (iv) the same trace; and (ii) if  $A$  is invertible,  $B$  will be so, if  $A$  is singular so will  $B$ .

Different from Flegg et al. (2016) or Tobben and Kronenberg (2015), in this work there is not a matrix derived from a census, that serves as basis for comparison, i.e., there is not a "real interregional system" used as reference to identify the most accurated method. The aim is to evaluate if the systems estimated by SUIT and IIOAS are divergent from each other. It would mean that the choice of the method can influence on the results of the input-output analysis.

In order to evaluate partitive accuracy between estimated systems, two measures will be used: The Standardized Total Percentage Error - STPE and the Weighted Absolute Differential - WAD. According to Lahr (2001), these measures are recurrent in the input-output literature.

The STPE was initially used by Leontief (1986) and later by Jalili (2000) and Lahr (2001) and can be calculated:

$$STPE = 100 \frac{\sum_j \sum_i |a_{ij} - a_{ij}^*|}{\sum_j \sum_i a_{ij}} \quad (42)$$

Where  $a_{ij}$  is the  $i$ -th element of the  $j$ -th column in the technical coefficients matrix  $A$  with dimension  $(m \times n)$ , used as a reference, and  $a_{ij}^*$  is the same element of the estimated technical coefficient matrix  $A^*$ .

According to Wiebe and Lenzen (2016) STPE is non-symmetric, i.e., the percentage error may be different depending on the matrix used as reference. Therefore, in addition to the traditional STPE, it will be calculated:

$$STPE = 100 \frac{\sum_j \sum_i |a_{ij} - a_{ij}^*|}{\sum_j \sum_i [(a_{ij} + a_{ij}^*) / 2]} \quad (43)$$

Thus, the STPE results will be independent of the estimation method used as reference. The WAD, used in Lahr (2001), was developed to correct some problems of other measures, such as non-sensitivity to higher values and the existence of zeros in the matrices (which makes some measures indefinite). It is represented by:

$$WAD = \frac{\sum_j \sum_i (a_{ij} + a_{ij}^*) * |a_{ij} - a_{ij}^*|}{\sum_j \sum_i (a_{ij} + a_{ij}^*)} \quad (44)$$

The term  $(a_{ij} + a_{ij}^*)$  weights the absolute difference, so that the errors in the larger coefficients are emphasized. The STPE and WAD were used because they complement each other. The STPE has the advantage of presenting differences in percentage, but does not show great sensitivity to errors in high coefficients. The WAD has great sensitivity to discrepant values in high coefficients, however, it is an absolute measure, it does not present results in percentage.

The holistic accuracy will be identified by an analysis of: (i) Output multipliers; (ii) a Value Added decomposition of each UF among final demand of each UF; (iii) structural decomposition.

The output multipliers reveal the direct and indirect impacts on output due to changes of one monetary unit in final demand of each sector in each UF. The total

multiplier effect is obtained by the sum of columns of the Leontief inverse matrix<sup>4</sup>. The net output multipliers discount the effect of the injection of one monetary unit. It is obtained by subtracting the Leontief inverse from a same size identity matrix.

The regional Value Added decomposition, with respect to final demand origin, complements the analysis of output multipliers. For Guilhoto, Siroen and Yucer (2013), the Value Added decomposition may be a better measure than Gross Output to understand the impacts of the trade on regional employment and growth.

Considering domestic ( $v$ ) and external ( $e$ ) elements of final demand ( $Y$ ), VA decomposition can be obtained by pre-multiplication of the Leontief inverse matrix by the diagonalized Value Added coefficient - CVA (that is: VA divided by Gross Output).

$$\begin{aligned} VA^1 &= BCVA^{11}(v^{11} + \dots + v^{UF1} + e^1) + \dots + BCVA^{1UF}(v^{1UF} + \dots + v^{UFUF} + e^{UF}) \\ \vdots & \qquad \qquad \qquad \vdots & \qquad \qquad \qquad \vdots \\ VA^{UF} &= BCVA^{UF1}(v^{11} + \dots + v^{UF1} + e^1) + \dots + BCVA^{UFUF}(v^{1UF} + \dots + v^{UFUF} + e^{UF}) \end{aligned} \quad (45)$$

Where  $BCVA^{11}$  is the element of the Leontief Inverse matrix multiplied by diagonalized CVA. In this way, we can calculate the share of Value Added (in each UF) that is linked to its own final demand, final demand of other UFs and abroad.

Owen et al. (2014) and Owen (2017) used structural decomposition to analyze the variations in results obtained from the use of interregional input-output systems, built for the same regions, applying different methodologies. The authors used global databases such as WIOD; EORA and GTAP.

For the aim of this study, the structural decomposition of the total Gross Output variation ( $\Delta x$ ) between the systems estimated by IIOAS and SUIT can be made:

$$\begin{aligned} \Delta x &= 0,5 \left[ (\Delta L * YS^I * YV^I) + (\Delta L * YS^T * YV^T) \right] \text{(Technological effect)} \\ &+ 0,5 \left[ (L^T * \Delta YS * YV^I) + (L^I * \Delta YS * YV^T) \right] \text{(Final demand structure effect)} \\ &+ 0,5 \left[ (L^T * YS^T * \Delta YV) + (L^I * YS^I * \Delta YV) \right] \text{(Final demand volume effect)} \end{aligned} \quad (46)$$

Where:

$$YS^I = DF^I * inv[diag(YV^I)] \quad (47)$$

$$YS^T = DF^T * inv[diag(YV^T)] \quad (48)$$

$$YV^I = [e' * DF^I]' \quad (49)$$

$$YV^T = [e' * DF^T]' \quad (50)$$

$$\Delta L = L^T - L^I \quad (51)$$

$$\Delta YS = YS^T - YS^I \quad (52)$$

$$\Delta YV = YV^T - YV^I \quad (53)$$

Where  $L^T$  is the SUIT Leontief inverse;  $DF^T$  is the SUIT final demand;  $L^I$  is the IIOAS Leontief inverse;  $DF^I$  is the IIOAS final demand and  $e'$  is a row vector of ones used to sum final demands.

The Structural Decomposition identifies differences between interregional input-output systems estimated by SUIT and IIOAS. These differences may come from three different effects, named: (i) technology, (ii) final demand structure, and (iii) final demand volume.

In this analysis, the sum of the mentioned structural decomposition effects will be zero. It's because the regional Gross Output used in SUIT and IIOAS are the same. However, the intraregional and interregional trade flows and the final demand vectors

<sup>4</sup> To know how to calculate Leontief inverse matrix, see Miller and Blair (2009)

estimated by these two methods are different. In this way, it is possible to identify each effect independently.

#### 4. Results

The Leontief inverse<sup>5</sup> determinants estimated by SUI and IIOAS were quite different (Det. IIOAS =  $1.016 \times 10^{20}$  and Det. SUI =  $3.866 \times 10^{26}$ ). The traces, on the other hand, were very similar (IIOAS = 1885.53 and SUI = 1901.06). The mean percentage difference between eigenvalues calculated from Leontief inverse, estimated by IIOAS and SUI was 2%, with a standard deviation of 2%.

Despite some close values, especially with respect to traces and eigenvalues, the Leontief inverse estimated by SUI and IIOAS can not be considered mathematically similar. However, it does not mean that these matrices can not be similar in economic terms.

The first step is to observe if there is some bias in the technical coefficients matrices, estimated by SUI and IIOAS, i.e., if the technical coefficients matrix estimated by one method is systematically higher/lower than the technical coefficients matrix estimated by the other method.

The technical coefficient matrix estimated by IIOAS presented 46% of its values lower than those estimated by SUI. None of the estimated matrices showed any pattern of behavior, with coefficients estimated by SUI being exclusively higher/lower than those estimated by IIOAS.

Regarding the partitive accuracy, the STPE was computed using as base both, technical coefficients of SUI and IIOAS, as well as their average.

The STPE calculated using as base the average of SUI and IIOAS coefficients presented a standardized total percentage error of 54.45%, for interregional system as a whole. Table 1 presents the results for STPE and the WAD in each UF.

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<sup>5</sup> Since the technical coefficients matrices are not invertible (they have correlated lines or columns), we measure the similarity between the Leontief inverses.

**Table 1: Partitive accuracy using STPE and WAD for 27 Brazilian UFs.**

UF	STPE						WAD	
	Intraregional			Interregional			Intraregional	Inter regional
	Base SUIT	Base IIOAS	Average	Base SUIT	Base IIOAS	Average		
<b>RO</b>	37%	42%	39%	72%	66%	69%	0.0211	0.0099
<b>AC</b>	42%	46%	44%	75%	72%	74%	0.0239	0.0096
<b>AM</b>	35%	31%	33%	71%	68%	70%	0.0226	0.0059
<b>RR</b>	43%	45%	44%	72%	74%	73%	0.0180	0.0101
<b>PA</b>	26%	28%	27%	70%	70%	70%	0.0156	0.0098
<b>AP</b>	45%	44%	44%	65%	68%	66%	0.0213	0.0083
<b>TO</b>	41%	46%	43%	65%	64%	65%	0.0204	0.0079
<b>MA</b>	46%	42%	44%	92%	66%	77%	0.0271	0.0075
<b>PI</b>	42%	44%	43%	71%	70%	71%	0.0195	0.0088
<b>CE</b>	33%	36%	34%	88%	72%	79%	0.0178	0.0081
<b>RN</b>	41%	46%	43%	75%	75%	75%	0.0209	0.0064
<b>PB</b>	44%	44%	44%	85%	77%	81%	0.0148	0.0111
<b>PE</b>	36%	34%	35%	106%	75%	88%	0.0164	0.0116
<b>AL</b>	42%	46%	44%	78%	74%	76%	0.0250	0.0057
<b>SE</b>	40%	47%	43%	78%	75%	76%	0.0296	0.0082
<b>BA</b>	27%	32%	29%	71%	65%	68%	0.0179	0.0071
<b>MG</b>	31%	37%	34%	75%	63%	69%	0.0215	0.0103
<b>ES</b>	54%	46%	50%	117%	69%	87%	0.0226	0.0112
<b>RJ</b>	28%	35%	32%	118%	72%	89%	0.0175	0.0163
<b>SP</b>	22%	25%	23%	113%	70%	87%	0.0155	0.0095
<b>PR</b>	34%	39%	36%	86%	71%	78%	0.0174	0.0139
<b>SC</b>	35%	33%	34%	88%	65%	75%	0.0175	0.0106
<b>RS</b>	24%	26%	25%	74%	66%	69%	0.0144	0.0070
<b>MS</b>	37%	39%	38%	84%	66%	74%	0.0182	0.0141
<b>MT</b>	37%	43%	40%	64%	65%	65%	0.0219	0.0081
<b>GO</b>	37%	43%	40%	77%	63%	70%	0.0177	0.0088
<b>DF</b>	36%	45%	40%	93%	67%	78%	0.0203	0.0087
<b>Average</b>	37%	39%	38%	82%	69%	75%	0.020	0.009
<b>Max</b>	54%	47%	50%	118%	77%	89%	0.0296	0.016
<b>Min</b>	22%	25%	23%	64%	63%	65%	0.014	0.006
<b>S-D</b>	7%	7%	7%	15%	4%	7%	0.004	0.003

Source: Research data

Regarding STPE, the lowest intraregional standard percentage difference between technical coefficients estimated by SUIT and IIOAS occurred in São Paulo state - SP (23.3%) and the highest in Espírito Santo - ES (49.8%). Considering all UFs, the mean difference between the methods was (38%). For interregional technical coefficients, the differences are higher. The highest interregional STPE was in Santa Catarina - SC (74.72%) and the lowest was in Mato Grosso - MT (64.61%).

In general terms, when SUIT coefficients are used as base, the mean difference for intraregional flows are very similar to those calculated using IIOAS coefficients. Regarding interregional flows, the mean difference, when using SUIT coefficients as

base, are larger than when using IIOAS. This indicates that the interregional flows estimated by SUIT are, in general, lower than those estimated by IIOAS.

According to Oosterhaven (2005) and Barros & Guilhoto (2014), the simple locational quotient (QL) and interindustry coefficient (CIQ), used in SUIT, tend to overestimate intraregional flows and to underestimate interregional flows, mainly because QL and CIQ minimize the interregional cross-hauling, implicitly or explicitly.

Regarding WAD, the UF with the greatest absolute weighted difference was Sergipe - SE (0.030) and the lowest was Rio Grande do Sul - RS (0.014), taking into account that this measure has great sensitivity to differences between larger coefficients.

STPE and WAD results show that the differences between interregional trade flows, estimated by SUIT and IIOAS, among Brazilian UFs are larger than intraregional flows. However, even with greater differences, there is a high positive correlation between interregional flows estimated by SUIT and IIOAS.

Table 2 presents the Pearson correlation coefficients between interstate trade flows for aggregated sectors of the economy, estimated by SUIT and IIOAS. It can be seen that the correlation was high for all sectors, as well as for the whole elements of intermediate consumption (94.06%).



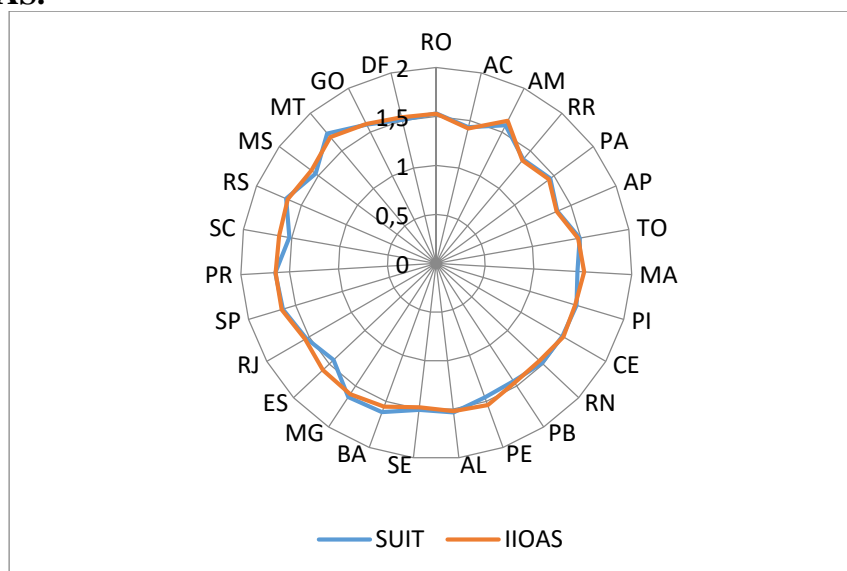
**Table 2: Correlation between interregional flows estimated by SUIT and IIOAS for aggregated sectors.**

Sectors	Correlation
Agriculture, livestock and forestry	71.18%
Manufactures	96.21%
Public administration	91.91%
Construction	90.15%
Sevices	95.88%
Total	94.06%

Source: Research data

Regarding holistic accuracy, the first element to be analyzed are the output multipliers. Figure 1 shows the average output multipliers, weighted by Value Added, for the 27 Brazilian UFs. It can be noted that the states of Espírito Santo - ES and Santa Catarina - SC show the greatest differences. In these two states, the output multipliers estimated by SUIT are lower than those estimated by IIOAS.

**Figure 1: Average Output Multipliers, weighted by Value Added, estimated from SUIT and IIOAS.**



Source: Research data

Regional Value Added and Gross Output are the same in SUIT and IIOAS. Then, the differences in multipliers calculated from SUIT and IIOAS are mainly due to the way that these methods deal with imports. The relation is: the size of imports influences the size of intermediate consumption, which directly influences the magnitude of multipliers.

Table 3 presents some statistics about the difference between output multipliers estimated by SUIT and IIOAS, considering the 68 sectors within each UF. The first column shows the number of common sectors among the 10 highest output multipliers estimated from each method. Except for Maranhão - MA and Amazonas - AM, for all UFs this number is equal to or greater than seven. It is also verified that there is a high correlation between the sectoral multipliers within each UF.

For almost all UFs, the mean percentage difference between output multipliers (within the UFs) was below 2%, but the standard deviation in some UFs was higher than the mean.

**Table 3: Statistics of the percentage difference between output multipliers estimated from IIOAS and SUIT for Brazilian UFs.**

UF	Common sectors	Correlation Ranking	Correlation coefficients	Max	Min	Average	S-D
RO	9	0.9836	0.9836	3.99%	0.00%	0.40%	0.72%
AC	8	0.9912	0.9825	3.68%	0.00%	0.43%	0.62%
AM	6	0.9635	0.9752	5.85%	0.00%	1.12%	1.04%
RR	9	0.9917	0.9873	3.19%	0.00%	0.39%	0.54%
PA	7	0.9833	0.9893	2.95%	0.00%	0.45%	0.47%
AP	7	0.9908	0.9892	3.66%	0.00%	0.41%	0.63%
TO	8	0.9897	0.9893	3.66%	0.00%	0.50%	0.50%
MA	5	0.8725	0.8638	12.68%	0.00%	2.69%	2.33%
PI	9	0.9889	0.9869	3.98%	0.00%	0.42%	0.59%
CE	7	0.9627	0.9725	5.00%	0.00%	0.71%	0.93%
RN	8	0.9948	0.9949	1.86%	0.00%	0.69%	0.37%
PB	8	0.9629	0.9664	6.01%	0.00%	0.90%	1.12%
PE	7	0.9069	0.9055	10.76%	0.00%	2.39%	1.89%
AL	7	0.9922	0.9821	3.06%	0.00%	0.41%	0.53%
SE	8	0.9920	0.9933	1.64%	0.00%	0.55%	0.32%
BA	9	0.9943	0.9961	2.29%	0.00%	1.12%	0.49%
MG	10	0.9897	0.9921	2.06%	0.00%	0.57%	0.37%
ES	7	0.7510	0.7194	17.47%	0.00%	4.04%	3.19%
RJ	8	0.9811	0.9856	4.46%	0.00%	0.67%	0.71%
SP	8	0.9785	0.9815	3.97%	0.00%	0.47%	0.71%
PR	7	0.9840	0.9867	3.71%	0.00%	0.35%	0.59%
SC	7	0.8873	0.8889	10.74%	0.00%	2.44%	1.94%
RS	9	0.9874	0.9907	2.36%	0.00%	0.40%	0.42%
MS	7	0.9402	0.9511	8.40%	0.00%	1.45%	1.45%
MT	9	0.9934	0.9921	2.11%	0.00%	0.92%	0.43%
GO	8	0.9778	0.9749	5.40%	0.00%	0.55%	0.95%
DF	7	0.9675	0.9583	6.36%	0.00%	1.09%	1.12%

Source: Research data.

Table 4 presents the percentage differences between interregional and intraregional multipliers, net and total, for each UF estimated from IIOAS and SUIT.

**Table 4: Percentage differences between interregional and intraregional multipliers estimated from SUIT and IIOAS for Brazilian UFs.**

UF	TOTAL		NET	
	INTRA	INTER	INTRA	INTER
RO	1.9%	4.3%	10.0%	2.3%
AC	1.1%	3.0%	3.2%	0.8%
AM	0.3%	0.9%	7.3%	7.0%
RR	0.4%	1.1%	3.6%	3.5%
PA	0.5%	1.4%	3.1%	0.6%
AP	0.9%	2.2%	10.2%	5.9%
TO	0.6%	1.4%	3.7%	0.6%
MA	7.8%	21.9%	8.3%	2.3%
PI	0.2%	0.5%	1.3%	2.8%
CE	4.1%	14.0%	11.3%	6.8%
RN	0.2%	0.6%	5.8%	1.4%
PB	2.6%	6.8%	2.6%	1.0%
PE	6.9%	24.1%	11.9%	7.3%
AL	1.6%	4.8%	8.2%	2.5%
SE	1.1%	3.1%	8.0%	2.5%
BA	1.9%	6.4%	11.7%	7.8%
MG	3.9%	12.8%	15.8%	11.3%
ES	11.4%	38.3%	16.5%	8.2%
RJ	8.1%	35.9%	22.8%	26.4%
SP	6.3%	35.5%	16.8%	29.4%
PR	4.8%	15.0%	17.7%	11.7%
SC	6.9%	22.9%	12.0%	6.7%
RS	3.1%	10.8%	11.0%	8.4%
MS	6.5%	17.2%	16.8%	7.3%
MT	0.5%	1.2%	8.3%	2.5%
GO	4.9%	13.1%	17.7%	7.8%
DF	7.4%	21.7%	24.0%	11.7%
Average	3.5%	11.9%	10.7%	6.9%
Max	11.4%	38.3%	24.0%	29.4%
Min	0.2%	0.5%	1.3%	0.6%
S-D	3%	12%	6%	7%

Source: Research data

The decomposition of the Value Added of each UF between the final demand of each UF is also relevant for the holistic accuracy, and complements the output multipliers analysis. Table 5 presents the percentage difference between Regional Value Added linked to the final demand of each UF estimated from SUIT and IIOAS.

The highest differences (positive or negative) between the values estimated based on SUIT and IIOAS were for Bahia - BA, Rio de Janeiro - RJ and Distrito Federal - DF, and the lowest were for São Paulo - SP, Santa Catarina - SC and Rondônia - RO.

**Table 5: Differences in Decomposition of Regional Value Added based on the origin of Final Demand (SUIT - IIOAS)**

UF		ORIGIN																											
		RO	AC	AM	RR	PA	AP	TO	MA	PI	CE	RN	PB	PE	AL	SE	BA	MG	ES	RJ	SP	PR	SC	RS	MS	MT	GO	DF	EXPORT
VALUE ADDED	RO	-0,3%	0,1%	-2,2%	0,0%	-0,1%	0,1%	0,0%	0,2%	0,4%	0,4%	0,4%	0,5%	0,6%	0,1%	0,4%	0,7%	0,4%	0,1%	0,6%	-2,8%	-0,2%	1,1%	-0,6%	-0,1%	-0,1%	-0,1%	0,8%	-0,2%
	AC	-0,7%	5,6%	-2,4%	0,0%	0,1%	0,0%	0,0%	0,1%	0,1%	-0,2%	0,1%	0,1%	0,1%	0,0%	0,1%	0,8%	0,3%	0,1%	1,9%	-3,6%	-0,3%	0,6%	-0,6%	0,0%	-0,3%	-0,4%	-1,1%	-0,4%
	AM	-0,4%	-0,1%	-5,6%	-0,2%	-0,3%	-0,1%	0,0%	0,1%	0,3%	0,2%	0,1%	0,3%	0,8%	0,0%	0,1%	0,4%	1,2%	0,4%	3,1%	0,5%	0,5%	0,1%	-0,2%	0,1%	-0,2%	-0,1%	-0,7%	-0,3%
	RR	-0,1%	-0,1%	-8,0%	5,5%	0,0%	0,0%	0,0%	0,0%	0,1%	0,0%	0,1%	0,1%	0,1%	0,1%	0,0%	0,7%	0,9%	0,2%	1,7%	-0,9%	0,2%	0,5%	-0,2%	0,0%	0,0%	-0,1%	-0,6%	-0,1%
	PA	-0,1%	0,0%	-0,6%	0,0%	7,8%	0,0%	-0,1%	0,3%	-0,1%	-0,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,3%	-0,1%	0,3%	-3,5%	-0,4%	-0,1%	-0,8%	0,0%	-0,1%	-0,3%	-0,4%	-1,3%
	AP	-0,1%	-0,1%	-1,3%	0,0%	-0,1%	7,2%	-0,1%	-0,1%	0,0%	-0,3%	-0,1%	0,0%	-0,2%	0,0%	-0,1%	-0,1%	0,1%	-0,1%	1,0%	-3,6%	-0,3%	0,3%	-0,7%	0,0%	0,0%	-0,3%	-0,5%	-0,7%
	TO	0,0%	0,0%	-0,6%	0,0%	1,0%	0,0%	8,6%	0,5%	0,2%	0,0%	0,3%	0,1%	0,1%	0,0%	0,0%	-0,7%	-0,4%	0,1%	0,6%	-4,7%	-0,5%	0,0%	-1,1%	0,0%	-0,1%	-0,6%	-2,5%	-0,3%
	MA	0,0%	0,0%	-0,8%	0,0%	-0,2%	0,0%	0,6%	9,1%	0,0%	-0,7%	-0,1%	-0,1%	-0,4%	-0,1%	-0,1%	-0,4%	0,0%	-0,1%	-0,2%	-4,3%	-0,3%	-0,1%	-0,7%	0,0%	0,0%	-0,4%	-0,7%	0,2%
	PI	0,1%	0,0%	-0,7%	0,0%	-0,6%	0,0%	-0,1%	1,4%	7,2%	-0,9%	-0,3%	0,0%	-0,2%	-0,1%	-0,1%	-1,0%	-0,1%	-0,2%	0,8%	-3,2%	-0,1%	0,1%	-0,4%	0,0%	-0,1%	-0,3%	-1,0%	-0,3%
	CE	0,1%	0,0%	-0,5%	0,0%	-0,1%	0,0%	0,0%	-0,2%	0,0%	3,4%	0,1%	-0,1%	-1,1%	0,1%	0,0%	-0,8%	0,0%	0,0%	1,8%	-2,3%	0,1%	0,5%	0,1%	0,0%	0,0%	-0,2%	-0,6%	-0,1%
	RN	0,2%	0,0%	-0,7%	0,0%	0,1%	0,0%	0,1%	-0,1%	-0,1%	-1,8%	5,3%	-2,0%	-2,6%	0,0%	-0,1%	-0,8%	1,1%	-0,1%	1,2%	-1,4%	0,6%	0,7%	0,0%	0,1%	0,1%	0,3%	-0,2%	0,0%
	PB	0,0%	0,0%	-0,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,2%	-1,2%	8,7%	-3,1%	-0,4%	0,0%	-0,6%	0,4%	-0,1%	0,3%	-2,4%	0,0%	0,3%	-0,4%	0,0%	0,0%	-0,2%	-0,4%	-0,2%
	PE	0,0%	0,0%	-0,4%	0,0%	0,0%	0,0%	0,0%	-0,1%	0,0%	0,1%	-0,2%	-1,2%	4,6%	-0,2%	0,0%	-0,4%	-0,2%	0,0%	0,7%	-2,2%	0,1%	0,4%	-0,2%	0,1%	0,0%	-0,3%	-1,0%	0,3%
	AL	0,1%	0,0%	-0,6%	0,0%	0,1%	0,0%	0,0%	0,1%	0,0%	-0,4%	-0,2%	-0,2%	-1,6%	4,6%	-0,3%	-1,6%	0,0%	0,0%	1,8%	-3,0%	0,3%	0,7%	0,2%	0,0%	-0,1%	-0,4%	-0,7%	1,4%
	SE	0,0%	0,0%	-0,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,5%	-0,3%	-0,2%	-0,8%	-0,5%	7,4%	-0,5%	0,2%	-0,3%	0,6%	-3,2%	0,2%	0,2%	-0,3%	0,0%	-0,1%	0,0%	-0,8%	-0,3%
	BA	0,1%	0,0%	-0,3%	0,0%	0,1%	0,0%	0,0%	0,0%	0,0%	-0,3%	0,0%	0,0%	-0,2%	-0,1%	-0,2%	11,6%	-1,1%	-0,6%	-0,1%	-3,6%	-0,4%	-0,1%	-1,0%	0,0%	-0,1%	-0,7%	-2,1%	-0,6%
	MG	0,0%	0,0%	-0,3%	0,0%	0,1%	0,0%	0,0%	0,1%	0,1%	-0,1%	0,0%	0,1%	-0,1%	0,0%	0,0%	0,3%	8,5%	0,0%	0,2%	-5,0%	-0,5%	-0,4%	-0,5%	-0,1%	-0,1%	-1,1%	-0,7%	-0,4%
	ES	0,1%	0,0%	-0,1%	0,0%	0,3%	0,0%	0,1%	0,2%	0,1%	0,2%	0,1%	0,2%	0,3%	0,1%	0,2%	-0,4%	-0,3%	4,6%	-2,1%	-2,0%	0,1%	0,1%	0,3%	0,0%	0,1%	-0,2%	-0,3%	-1,9%
	RJ	0,1%	0,0%	0,0%	0,0%	0,5%	0,0%	0,1%	0,3%	0,1%	0,1%	0,1%	0,2%	0,1%	0,1%	0,1%	0,3%	-1,2%	0,0%	10,5%	-9,2%	-0,7%	-0,4%	-0,4%	-0,1%	0,0%	-0,3%	-0,6%	0,0%
	SP	0,0%	0,0%	-0,3%	0,0%	0,4%	0,0%	0,0%	0,2%	0,2%	0,0%	0,1%	0,1%	0,2%	0,0%	0,1%	0,0%	-0,1%	0,2%	-0,6%	1,8%	-1,6%	-0,3%	-0,8%	-0,2%	-0,2%	0,2%	0,3%	0,3%
	PR	0,2%	0,1%	0,0%	0,0%	0,9%	0,1%	0,1%	0,5%	0,3%	0,2%	0,2%	0,3%	0,3%	0,2%	0,2%	1,1%	0,4%	0,0%	-0,2%	-9,4%	5,4%	-0,6%	0,2%	0,0%	0,2%	-0,1%	-0,4%	0,0%
	SC	0,2%	0,1%	-0,1%	0,0%	0,7%	0,1%	0,1%	0,2%	0,2%	0,4%	0,2%	0,3%	0,6%	0,2%	0,1%	0,7%	0,5%	0,4%	1,1%	-4,6%	-0,3%	1,6%	-1,7%	0,0%	0,0%	-0,1%	-0,3%	-0,2%
	RS	0,0%	0,0%	-0,3%	0,0%	0,3%	0,0%	0,0%	0,1%	0,1%	0,2%	0,1%	0,1%	0,1%	0,1%	0,1%	0,0%	-0,2%	0,0%	-0,3%	-4,8%	-0,5%	-0,6%	7,3%	0,0%	-0,1%	-0,3%	-0,9%	-0,3%
	MS	-0,1%	0,0%	-0,5%	0,0%	0,2%	0,0%	0,0%	0,2%	0,2%	0,2%	0,1%	0,2%	0,2%	0,1%	0,1%	0,5%	-0,3%	-0,1%	0,3%	-5,7%	0,4%	0,4%	-0,1%	4,9%	-0,2%	-0,6%	-0,7%	0,2%
	MT	0,1%	0,0%	-0,8%	0,0%	0,1%	0,0%	0,0%	0,2%	0,3%	0,1%	0,1%	0,2%	0,3%	0,1%	0,1%	1,0%	0,1%	0,0%	2,1%	-4,5%	0,5%	0,5%	-0,7%	0,0%	1,8%	-0,3%	-0,7%	-0,7%
	GO	0,2%	0,1%	-0,3%	0,0%	0,9%	0,1%	0,2%	0,5%	0,3%	0,1%	0,2%	0,3%	0,2%	0,1%	0,1%	1,5%	-0,5%	-0,1%	0,0%	-6,4%	0,1%	-0,2%	-0,5%	0,0%	0,1%	4,7%	-1,7%	0,0%
	DF	0,0%	0,0%	-0,4%	0,0%	-0,1%	0,0%	0,0%	0,0%	0,0%	-0,7%	0,0%	0,1%	-0,5%	-0,1%	-0,1%	0,5%	-1,5%	-0,4%	-0,3%	-7,1%	-0,4%	-0,2%	-1,4%	-0,1%	-0,3%	-1,1%	14,7%	-0,2%

Source: Research data

Table 6 shows the percentage variations resulting from (i) technological, (ii) final demand structure, and (iii) final demand volume differences between SUIT and IIOAS estimated systems. In order to carry out this analysis average regional differences in module were used, to ensure that negative differences not cancel positive differences. Moreover, these variations were weighted by the share of regional gross output (for a sector  $i$ ) in the total regional gross output so as to guarantee the proportionality.

**Table 6: Regional average percentage difference, weighted by the share of regional gross output of the sector  $i$  in the total regional gross output.**

UF	Tecnological	Final demand structure	Final demand volume
RO	2.9%	3.7%	3.4%
AC	3.9%	5.4%	4.5%
AM	6.2%	7.8%	4.1%
RR	4.2%	6.7%	4.9%
PA	4.2%	5.1%	3.9%
AP	4.6%	6.9%	4.7%
TO	4.8%	6.3%	4.4%
MA	5.5%	7.4%	3.6%
PI	4.0%	5.3%	4.2%
CE	4.9%	6.5%	4.1%
RN	3.7%	6.7%	4.7%
PB	4.4%	5.5%	4.5%
PE	4.7%	5.4%	3.7%
AL	6.3%	7.1%	5.0%
SE	4.2%	5.0%	4.8%
BA	3.6%	3.1%	3.1%
MG	2.3%	3.5%	2.9%
ES	4.8%	4.5%	2.6%
RJ	3.6%	3.6%	2.9%
SP	1.9%	3.5%	2.6%
PR	4.8%	5.6%	3.3%
SC	4.2%	4.8%	3.2%
RS	3.3%	4.4%	2.6%
MS	5.7%	7.1%	3.2%
MT	4.4%	5.6%	2.6%
GO	2.7%	5.2%	3.7%
DF	4.5%	9.7%	5.6%
Max.	6.32%	9.68%	5.60%
Min.	1.89%	3.15%	2.56%
Average	4.23%	5.61%	3.80%

Source: Research data

According to Table 7, the highest differences between the two methods are in final demand structure. Part of these differences can be attributed to the way in which SUIT and IIOAS deal with inventories.

**Table 7: Structure and volume of final demand for SUIT and IIOAS**

<b>Final demand</b>	<b>Correlation</b>	<b>SUIT</b>	<b>IIOAS</b>	<b>% Difference</b>
All elements of final demand	0.9988	4,387,146.72	4,352,677.68	0.7%
Investment	0.999	775,685.03	774,985.99	0.1%
Household consumption	0.994	2,239,017.69	2,173,854.93	3.0%
Government expenditures	0.996	817,368.00	878,087.74	7.2%
Exports	1.000	501,802.00	501,802.00	0.0%
Inventories	0.311	53,274.00	23,947.03	76.0%
Inventories (module)	0.309	72,874.58	125,290.00	52.9%
Inventories (module) service sectors	0.086	248.11	51,689.21	198.1%

Source: Research data

The inventories estimated from SUIT and IIOAS showed the lowest correlation, both for absolute value and module. This correlation is even smaller when we consider only the service sectors.

However, the inventories in both methods are sufficiently low, so as not to compromise the totals of the final demand. The correlation between the sum of the final demand elements is 0.998.

Turning to Table 6, the technological differences come from differences in Leontief inverse estimated by SUIT and IIOAS, which in turn, come from the way that each method treat imports, as already mentioned.

However, in addition to the differences in imports, differences in the way in which SUIT and IIOAS estimate their intraregional and interregional trade flows should be considered. SUIT intraregional trade flows are estimated using the CIQ, which is based on the share of regional Gross Output in national Gross Output (of each product). The interregional flows also use the share of regional Gross Output of a given product (in the origin region) in the national production of this product, discounting the production of the destination region.

On the other hand, IIOAS uses the domestic regional supply and demand ratio to compute intraregional trade flows. For interregional trade flows IIOAS uses the share of origin region domestic supply in the national domestic supply, multiplied by an impedance coefficient, based on travel time between each origin-destination pair.

Therefore, SUIT technical coefficients will be lower than IIOAS technical coefficients whenever a region has a trade flow determined by its share in domestic output lower than that determined by the impedance coefficient, i.e., its share in the national production will be adversely affected by the distance.

## 5. Final Remarks

This paper aimed to identify the differences between interregional input-output systems, built for the 27 Brazilian UFs, using the SUIT and IIOAS methods.

After describing each method, it can be seen that the two methods are consistent with the national Input-Output Matrix and with the Regional Accounts. In addition, both methods can be applied in the construction of interregional input-output systems for any country that publishes its Supply and Use Tables and has some subnational information for regionalization.

Regarding the application, IIOAS presents greater facility for systems among same level regions, e.g. 27 Brazilian UFs. On the other hand, SUIT shows greater flexibility when we are combining different regional levels. To apply IIOAS in an inter-

regional input-output system that contains a municipality, the rest of the state to which it belongs and the rest of the country to which this state belongs, it is necessary to build trade matrices for all municipalities of that state, which is not necessary when using SUIIT.

Evaluating the partitive accuracy, according to STPE and WAD, the interregional trade flows showed greater differences than intraregional trade flows, for both SUIIT and IIOAS. In spite of that, the interregional trade flows estimated by SUIIT and IIOAS showed high correlation and low dispersion for all the analyzed regions and sectors.

Concerning the holistic accuracy between the estimated systems, SUIIT and IIOAS output multipliers showed high positive correlation. The average difference between the sectoral output multipliers within each region was less than 2%. In addition, the ranking of sectoral output multipliers within each region showed high correlations, with at least 7 common sectors out of the 10 largest estimated multipliers by each system.

When considering intraregional and interregional parts individually, the difference between output multipliers estimated by these methods increases, especially regarding interregional portions. The differences in the decomposition of Value Added of each UF linked to the final demand of each UF were, on average, around 10%, but also with a high standard deviation.

The structural decomposition analysis was made to evaluate differences in technology, structure and volume of final demand. The largest average difference was presented in the structure of the final demand (5.6%), mainly due to the differences in the inventories. However, this is not enough to influence the total of final demand, because inventories represent a rather low final demand portion.

In this context, it can be concluded that, although the partitive accuracy presents some apparently high differences between the estimated systems, it is not enough to influence the results of input-output analysis, when choosing between an interregional system estimated by SUIIT or IIOAS.

However, for specific studies that involve a particular sector or region, especially if it is in the North of Brazil, the analyst should take into consideration the possible variations observed in the present study.

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