Building a 2005 hybrid Brazilian input-output database

Rômulo N. Ely[a], Carolina Grottera[a], Mariana W. de Abreu[a] and William Wills[a]

[a] Energy Planning Program, Graduate School of Engineering, Universidade Federal do Rio de Janeiro, Centro de Tecnologia, Bloco C, Sala 211 Cidade Universitaria 21941-972 Ilha do Fundao, Rio de Janeiro, RJ, Brazil

Corresponding author: romulo@ppe.ufrj.br

Abstract: This study intends to present a methodology for augmenting the Brazilian Supply-Use Table (SUT) from '56 industries and 110 products' to '91 industries and 126 products'. The idea behind this disaggregation effort is to reach a more suitable table in terms of Green House Gases (GHG) emission to enable future climate change impact assessment. From this expanded SUT version we have estimated a couple of other Input-Output Tables (IOT). While the first one contains 91 industries, the second one is more compact, containing only 49, in which we have applied a hybridization process – computing not only the monetary units but also a set of goods and services flows in physical terms. The results show that our estimated database, when compared to the original data source, is consistent in terms of Gross Domestic Product (GDP), total output of industries in physical units and total labour force by industry. It demonstrates that this study can be a valuable guideline for other researchers who seek to build a similar database or even to replicate this methodology for another region and for other purpose beyond the climate change issue.

***Keywords*—Hybrid Input-Output table, Supply-Use table, Computational General Equilibrium model, Energy, Brazil.**

Acknowledgments

This study was undertaken for the CLIMA project, which is part of the International Climate Initiative. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety supports this initiative on the basis of a decision adopted by the German Bundestag, and the project has been carried out in cooperation with Federal German Environment Agency. This study was also undertaken for the IES-Brasil project, which was forty percent supported by the Children's Investment Fund Foundation (CIFF) and sixty percent by institutions with interest in the objectives of the project. We would also like to thank AGROICONE (Marcelo Moreira and Leila Harfuch) that helped us providing detailed agricultural data for the hybridization process and Prof. Marcelo Pereira da Cunha from UNICAMP (State University of Campinas) for his contribution in the early stage of this work.

1) Introduction

Many studies have been seeking to assess the negative environmental impacts associated with economic activities. Greenhouse Gases (GHG) pursue a strong linkage with energy industries and land-use changes and are included in the most studied gases in terms of global environmental impacts. Therefore, many studies have been applying a bottom-up approach for capturing the energy consumption, land-use changes and industrial processes in order to evaluate GHG emissions from these different economic activities.

This is the case of the CLIMA (Integrated Modeling of the Land Use, Water and Energy Nexus of Brazilian Biofuels Expansion under Climate Change) and IES-Brasil (Social and Economic Implications: GHG Mitigation Scenarios 2030/2050) projects. The former project aims to inform policymakers and stakeholders on the potential biofuels expansion scenarios in Brazil under climate change until 2030 in order to mitigate adverse impacts on water resources, land use, and food security while promoting sustainable production of biofuels to mitigate GHG emissions. The latter aims to generate medium and long-term GHG emissions scenarios for Brazil, via a participative process involving the government, the private sector, academia and civil society. Both are implemented through a multi-institutional modeling effort that integrates basin-scale water resources assessment, land-use change and economy-wide modeling of socioeconomic and GHG impacts due to biofuels use and climate policy scenarios, respectively.

The quantitative analysis is supported by a stakeholder-process that aims to integrate expert knowledge into the analysis and facilitate dissemination of project findings for policy designing and sustainability initiatives. For achieving such goals, the Computational General Equilibrium (CGE) model, IMACLIM-S BR (Wills and Lefevre, 2012, Wills, 2013) will be coupled with a set of bottom-up models, as the Brazilian Land Use Model, BLUM (Nassar et al., 2011), MESSAGE (Model for Energy Supply Strategy Alternatives and their General Environmental Impact), LEAP (Long range Energy Alternatives Planning System), and other bottom-up analyses for transport, industrial, waste, among others. Thus, the input-output table (IOT) used by IMACLIM-S BR should be expanded in order to allow a more detailed assessment on the effects of a biofuels expansion on other agricultural goods production and prices, on food security and finally, on other economic sectors structural changes due to modeling different climate change scenarios for Brazil.

The debate around energy-economy started a few decades ago (Hogan and Manne, 1977), and has gained significant importance in the last decade due to a new problem faced by humanity, the climate change issue – see Bohringer (1998), Bohringer and Rutherford (2008), Bohringer and Rutherford (2009), Hourcade et al. (2006), Sue Wing (2004), Sue Wing (2008), among others. In order to assess the economic impacts from a climate policy, and because energy generation and consumption is very relevant in overall GHG emissions, it became very important to develop models that can combine this two different fields.

Historically, we can identify two "tribes" of E3[1] modeling to analyze energy and environment policies. On the one hand, bottom-up models can precisely describe the competition of technologies both in the demand and supply sides based on expert data and enable to project possible radically different technology future with significantly different impacts on the environment. The challenge is that energy models are generally very technologically detailed, in a bottom-up framework, while a top-down, general equilibrium model is required to analyze the economy-wide impacts of climate policies (Ghersi and Hourcade, 2006).

Although bottom-up models are highly sensitive from the technology point of view, the limitation of "conventional bottom-up" models is the poor macro and micro economic realism - a weakness in capturing: indirect economic, environmental and social effects between the industries (between a specific or many regions considered in the analysis) and to assess consumer and producer's behaviors in response to product's price changes.

Both issues are well covered by IO and CGE models, respectively. They have limitations to incorporate technological changes, being less sensitive to technological aspects. Such weaknesses can also affect their GHG emission estimations.

An "ideal model" should incorporate both qualities, inherent in both types of models. Figure 1 demonstrates it graphically, placing the models inside a three-dimensional space that is formed by "Microeconomic realism", "Macroeconomic completeness" and "Technological explicitness" (x, y and z, as the respective axis).

In order to build a model as similar as possible to this idea represented in the Figure 1, as aforementioned, we have developed an expanded hybrid IO Brazilian database for 2005 to be used by the CGE model IMACLIM-S BR. To reach such goal, we have first expanded the official 'Uses and Resources' Brazilian table from '56 industries and 110 products' to '97 industries and 125 products'. Our aim was to build a more suitable database, enabling relevant industries to be analyzed from the GHG emissions perspective.

In the next section we show the methodology applied for building such database. We start describing the database that we have used. Hereafter, we demonstrate the process to expand such database to a more disaggregated table, the recipe for transforming it in a sector-by-sector IOT, and then the logical behind its aggregation in a more compact table (unfortunately this aggregation was done due to the laborious downstream hybridization process and the hard task that treating a disaggregated IO

[1] Energy-Environment-Economy

database becomes in terms of CGE models). Lastly, we present the hybridization process. The section three, four and five are 'Results', 'Discussion' and 'Conclusion', respectively.

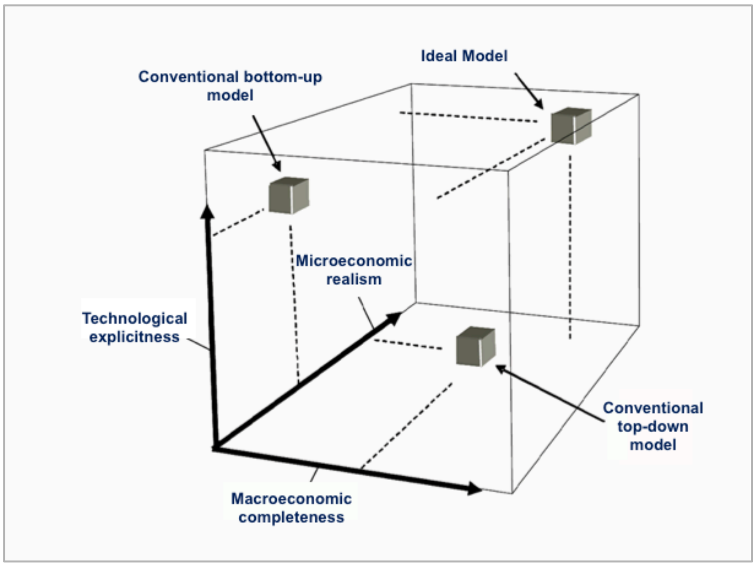

Figure 1 - Three-dimensional assessment of energy-economy models
Source: Hourcade et al. (2006)

2) Methodology

The Brazilian 'Uses and Resources' table is estimated by the Brazilian Institute of Geography and Statistics (IBGE), and it is available for download. Unfortunately, IBGE only provides this kind of data in purchaser's price. Instead of using it as a base for obtaining a Supply-Use table (SUT) in basic price - including its set of 'margins' and 'taxes on products' tables – we have decided to obtain these data from NEREUS, which also presents the methodology for estimation from the IBGE`s tables (Guilhoto and Sesso Filho, 2005, Guilhoto and Sesso Filho, 2010).

IOT and SUT represent the flows of goods and services between economic agents (industries, households, government and etc.) in an economic system. The logical behind the models is that both the input and the output are similarly represented in the tables. The first one represents what and how much the firms consume for producing something. The second one details for whom and how much the firms have sold the amount of their goods and/or services produced. The inputs are the columns while the outputs are the rows.

The following equations summarize the basic structure of these tables.

$$\text{IOT} = \begin{pmatrix} C_{i,i} & y_{i,n} \\ v_{m,i} & - \end{pmatrix} \tag{1}$$

$$\text{SUT} = \begin{pmatrix} - & V_{i,p} & - \\ U_{p,i} & - & y_{p,n} \\ v_{m,i} & - & - \end{pmatrix} \tag{2}$$

$$L_i = \text{Labour Force`s Satellite Account} \tag{3}$$

where $C_{i,i}$ is Intermediate Consume matrix of industry by industry (i,i), $y_{i,n}$ is the Final Demand matrix of i by n, which n representing the number of y components, $y_{p,n}$ is the Final Demand matrix of product (p) by n, $v_{m,i}$ is the Value Added matrix of m (v parts) by i, $V_{i,p}$ is the Production matrix of i by p, $U_{p,i}$ is the Use matrix of p by i, $y_{p,n}$ is the Final Demand matrix of p by n and L_i is the Labour Force`s Satellite Account vector.

The Final Demand (**y**) - usually partitioned by household, government, gross fixed capital formation, change in inventories and exports – is the demand of goods and services not for producing something, at least in the place where it was produced[2].

Value Added (**v**) is the matrix that represents the labour remuneration, profits, capital, margins, taxes, imports and so on. We also include a vector – Equation 3 - detailing the employment that each sector employs (**L**) – we call this kind of physical data – not internalized in the matrix, however, linked with IOTs (or SUTs) – as the satellite account.

The following equations represent the basic relationship between rows and columns – inputs and outputs. The balancing constrains show that the sum over rows elements must be equal to the sum over columns elements. Equation 4 is related to IOTs while Equation 5 and 6, SUTs.

$$\overbrace{(1^{\gamma t}\boldsymbol{C} + 1^{\alpha t}\boldsymbol{v})}^{z_i} - \overbrace{(\boldsymbol{C}1^{\gamma} + \boldsymbol{y}1^{\theta})^t}^{x_i} = \vec{0} \tag{4}$$

$$\overbrace{(1^{\beta t}\boldsymbol{U} + 1^{\alpha t}\boldsymbol{v})}^{z_i} - \overbrace{(\boldsymbol{V}1^{\beta})^t}^{x_i} = \vec{0} \tag{5}$$

$$\overbrace{(1^{\gamma t}\boldsymbol{V})}^{z_p} - \overbrace{(\boldsymbol{U}1^{\beta} + \boldsymbol{y}1^{\theta})^t}^{x_p} = \vec{0} \tag{6}$$

[2] Beyond the domestic border, these goods and services of the exports column vector can be used as an input by another industry

where z_i is the vector of total gross input of industries, $\boldsymbol{x_i}$ is the vector of total gross output of industries, $\boldsymbol{z_p}$ is the vector of total gross input of products, $\boldsymbol{x_p}$ is the vector of total gross output of products, $\boldsymbol{\gamma}$ is the number of industries, $\boldsymbol{\beta}$ is the number of products, α is the number of **v** elements, $\boldsymbol{\theta}$ is the number of y elements, t denotes transposition and 1^{γ}, 1^{β}, 1^{α} and 1^{θ} are the $\boldsymbol{\gamma}$, $\boldsymbol{\beta}$, $\boldsymbol{\alpha}$ and $\boldsymbol{\theta}$ vectors with one - e.g.: $\underbrace{(1, 1, \ldots, 1)}_{\gamma\ elements}$

The IBGE`s tables are available at different aggregation's levels: '12 industries and products', '42 industries and 80 products' and '56 industries and 110 products'. For this study we have used the last two, especially the latter one – the most disaggregated one – which we have called as "mother" table. A list with the 56 industries and 110 products is in the Appendix I and Appendix II, respectively. We have used the 42 industries table for supporting our disaggregation procedure in the second stage of the study. The reason for that is further explained in section 2.12.

The Figure 2 details the main four steps of the study. The first one, as mentioned before, is to obtain our original database – 2005 Brazilian SUT at basic prices – our mother table. The second represents our disaggregation step – which output is a more disaggregated SUT with 91 industries and 126 products. This is our "daughter" table.

In the step three, we transform our daughter table (a SUT) in an IOT. In fact, this is just a way to prepare such database for the next stage, the hybridization step, which outcomes the "granddaughter" table. It contains both financial and physical flows with its respective basic prices of most of the industries appraised. The steps two and four are the most time consuming of them.

The layers behind U, y and C tables - presented in all of the steps in the Figure 2 – are the imports, margins and taxes on products, estimated for all of the tables. Note that only the granddaughter table has eight layers, while the remaining have just seven. This is because we have estimated "specific margins" for the latter one. This type of margin is related to the existence of price differentiation in respect of consumers (e.g.: electricity can be cheaper for "manufacturing of steel and steel alloys" than for households). The other layers – margins and taxes on products (transport margins, trade margins, Imports Taxes, ICMS, IPI, Other Indirect Taxes) – are the same for all of the tables.

2.1) "Daughter" table's estimation

The biggest challenge in this step is to disaggregate the new industries and then balance the table. For the first task, firstly it is necessary to verify where the industries that we decided to disaggregate are originally (mother table) allocated. Secondly, how much its financial output was in 2005 (building our V matrix). As soon as these data are acquired, the "production recipe" and the output vector of these products can be estimated (building our U matrix: the production recipe and the output). Balancing the table is necessary because these procedures can modify the total inputs and total outputs of the table. Therefore, both an analytical and a numerical procedure have to be applied in order to optimize the SUT (or IOT) objective function.

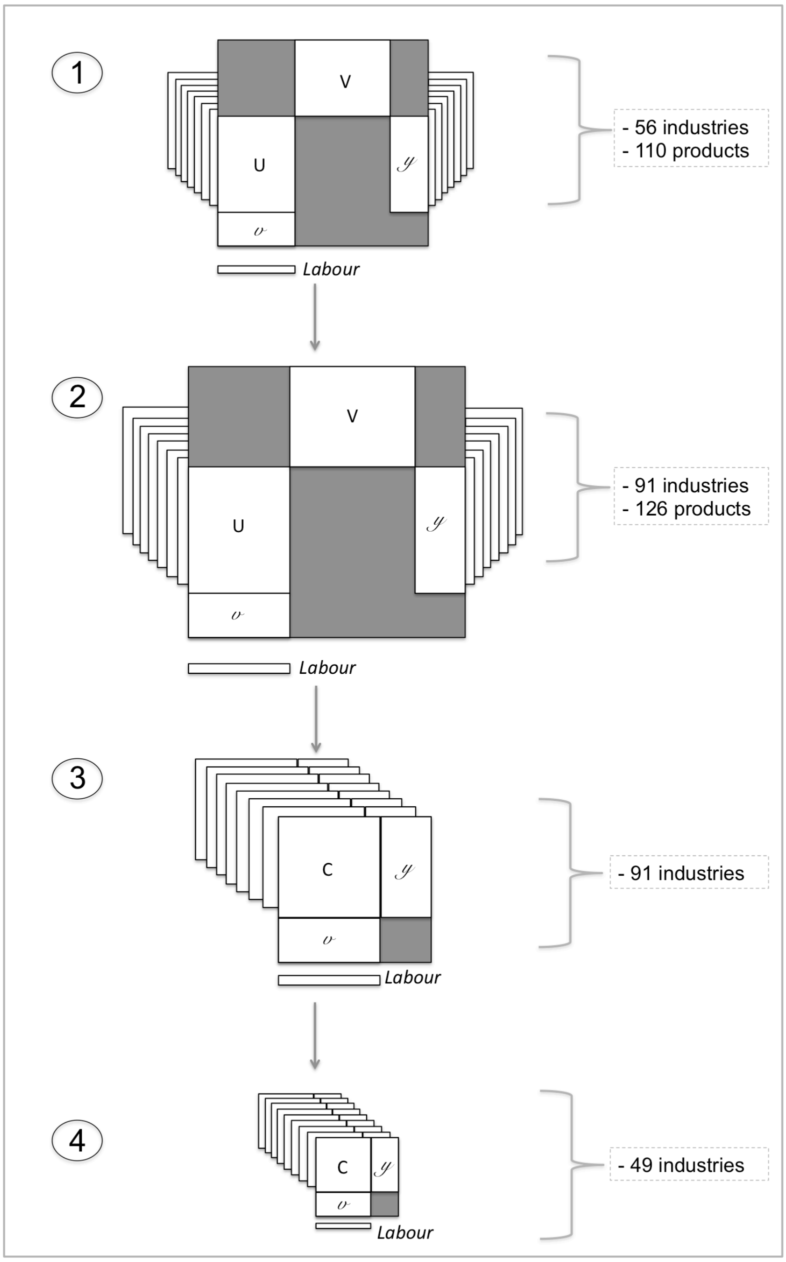

Figure 2 - Dataset estimation steps

2.1.1) Identifying "new" Industries and Products for our database

It is possible to verify in the Figure 4 (Appendix I) that 10 of the 56 industries were disaggregated in a set of new 44 industries. Biodiesel was an exception since it was not accounted in 2005. Then we had to estimate a new sector, assuming its hypothetical production for this year. This was implemented because such database was built for supplying a CGE model, especially for modeling Brazilian long-term climate change scenarios. Biodiesel production is a reality nowadays, so we decided to estimate this new sector to obtain a smooth adaptation during the next years by the CGE model.

The same decision was made for estimating the biodiesel product. However, comparing with industries, a smaller number of products had to be disaggregated. Despite the fact that 'forestry and silviculture' were put together – 110 of them were already accounted in the mother table. The Figure 4 in the Appendix II, shows that 10 products were disaggregated in 23 products.

2.1.2) Building our V matrix

The **V** matrix shows the output value of product ***p***, produced by the industry ***i***, showing how industries produce commodities (Miller and Blair, 2009). As soon as the sectors (that we have decided to estimate) are determined, the next step is to obtain the production value of each one. To this aim, we adopted different sources and assumptions. They can be verified in the Table 1.

Table 1 - Sources and/or assumptions for estimating "new" industries output values in the V matrix

Class of Industries/Products	Daughter`s table industry position	Source(s)/Assumption(s)
Forestry and Silviculture	1 - 6	SIDRA (2014)
Sugar cane	7	V matrix ("Mother table")
Soy grain	8	V matrix ("Mother table")
Grazing and Fishing	10-13	V matrix ("Mother table")
Crude Oil and Natural Gas	14 and 15	SIDRA (2014)
Mineral Coal	18	V matrix ("Mother table")
Food and Beverages	19-25	42x80 IBGE`s table, V matrix ("Mother table") and SIDRA (2014)
Gasohol and Diesel B	34 and 35	Fuels blending
Biodiesel	37	5% of Diesel B (B5)
Fertilizers	42	SIDRA (2014)
Ceramic, Glass and Lime	48-50	SIDRA (2014)
Electricity	66	Ramos (2014)
Transport	70-77	V matrix ("Mother table") and IBGE (2005)

As it is shown in the Table 1, IBGE produces most of the data that we need to build such table.

The only case that we have used another source to complement SIDRA (2014) was to obtain data for "Food and Beverages" class of industries/products, which appraises "Cattle and other meats", "Pork meat", "Chicken and other bird meat", "Sugar", "Soil oil" and "Dairy". The use of "42x80 IBGE`s table" was due to the fact that it is not just a simple aggregation of "56x110 IBGE`s table" - there are industries more disaggregated in such table. “Food and Beverages” class of industries is one that is presented in a more disaggregated way. Such values can also be extracted in the **V** matrix (mother table) that was also used for obtaining data for a great part of the industries that we decided to disaggregate.

Regarding ‘Transport’ class of industries/products: the **V** matrix from the mother table shows transport services products disaggregated in freight and passengers. Thus, we have complemented this information with data from IBGE (2005). This was crucial to estimate output values of the eight sectors related to transport.

Gasohol and Diesel B are a blending of Gasoline with Alcohol (anhydrous) and Diesel with Biodiesel, respectively. We have estimated the latter one considering that it must be 5% in physical units of Diesel B in 2005. We call this mixture in Brazil as B5. We have estimated electricity based in Ramos (2014).

After these data were obtained, we have subtracted each one of them from its respective original sector (from the mother table) - obtaining “Other agriculture sectors”, “Other mineral and ores”, “Other foods and beverages”, “Other chemical products”, “Gas, water, sewerage and drainage services” and “Rest of transport, storage and postal services”.

2.1.3) Building our U matrix: the “production recipe” and the output

The estimation of the production recipe and the output vector perhaps is the hardest task of the new industry estimation (or industry disaggregation) steps. The production recipe - or the technical coefficients - is the way that an industry produces something. It is the account of flows of goods, services and/or production factors consumed during the production process. From the SUT perspective, it consists in a column vector of **U** and **v**, related to a specific industry (***i***). The output vector is the vector related to a product - or a set of product (***p***) sold to the market, which means how much of this ***p*** each ***i*** and **y** parts consume during the assessed year.

We have applied different procedures to estimate these couple of vectors (production recipe and output) for each one of the new identified industries. For the ‘Forestry and Silviculture’ family sectors, Fertilizers, Ceramic, Glass and Lime, the procedure was the same. We have used a similar methodology applied in Malik et al. (2014) and Santos et al. (2015), which consists at identifying an isolated sector from another region (a distinct SUT – or IOT – database) and replicating its production recipe and output vector to the region that we want to assess. It is necessary to build concordance matrices for that – a binary matrix, in which ***i*** is the industry from one region while ***j*** is from another region – responsible to link the “foreigner” and the “domestic” SUT (or IOT). However, we have used imports and exports data extracted from the Brazilian system of analysis of foreign trade information

(AliceWeb). Also, for some elements of v matrix, we decided to apply a pro-rate function instead of replicating the foreigner **v** inputs.

Australian SUT was the "foreigner" country-model in the case of 'Forestry and Silviculture' class of sectors. We used "Forestry", "Softwood" and "Hardwood" industries as a base to estimate the Brazilian production recipe of these industries. Pro-rate function was also applied, using the values in **V** matrix as a proxy vector. The industry "Chemical Fertilizers" from the same country was used for estimating the Fertilizers production recipe and output vector. In the case of Ceramic, Glass and Lime industries estimation, we have used sectors from UK region, which are: "Manufacture of ceramic household and ornamental articles", "Manufacture of ceramic sanitary fixtures", "Manufacture of ceramic insulators and insulating fittings", "Manufacture of other technical ceramic products", "Manufacture of other ceramic products", "Manufacture of refractory ceramic products", "Manufacture of ceramic tiles and flags" - for Ceramic; "Manufacture of flat glass", "Shaping and processing of flat glass", "Manufacture of hollow glass", "Manufacture of glass fibres", "Manufacture and processing of other glass including technical glassware" - for Glass and; "Manufature of Lime" – for Lime.

The single SUTs (or IOTs) were extracted from Eora, the largest Multi-Regional Input-Output (MRIO) database at the time of writing (Lenzen et al., 2012, Lenzen, 2013). It is available for downloading at: www.worldmrio.com.

For the case of "Sugar cane" and "Soy grain" we based our production recipes and output vector estimation from Cunha (2014), which in a previous study (Cunha, 2011) have used information from Agrianual (2005) to estimate them.

Cunha (2011) also extracted information from BiodieselBR (2010) for the "Biodiesel" production recipe estimation, assuming that the main biodiesel feedstock was soy oil, which in fact represents 80% of its total production. We considered that the output of this industry is totally designated for the "Diesel B" consume, which production recipe is constituted by this product and diesel consumption.

A modification had to be applied for this fuel. We assumed that most part of the diesel is designated to "Diesel B", while the remaining amount is mostly sold to "Freight transport: ship" and "Passenger transport: ship" – as the ships engines are fed by pure diesel, not the B5 mixture.

We have applied the same production recipe estimation methodology for "Gasohol", considering as its inputs only gasoline and anhydrous alcohol. Differently than the "Diesel B" case, the total amount of gasoline is sold to this sector, which replaces the previous gasoline output vector presented in the "mother" table. We have employed a similar change in the case of gasoline product output sales vector, then.

The “42x80 IBGE`s table” was useful for building our production recipe and output vector of “Sugar”, “Soy oil” and “Dairy”. As these sectors were disaggregated in that table, we only had to use concordance tables for adapting it into the daughter`s table industries. A similar procedure was applied for estimating “Cattle and other meats”, “Pork meats” and “Chicken and other bird meats”. We have used the “Slaughtering” industry as a model, applying concordance tables and pro-rate function to estimate the production recipe and output vector of these sectors.

In the case of “Electricity” industry estimation, we have obtained information from Ramos (2014).

The “Mineral coal” estimation was based in Cunha (2014), which verified the main raw-materials related to this activity and reallocated them into the column and raw vectors. The same analytical procedure was applied for estimating “Crude oil”, “Natural gas” and the set of living stock and transport sectors – after we have applied pro-rate functions to disaggregate “Crude oil and natural gas”, “Grazing and fishing” and “Transport and postal services” industry, respectively. We have used the values of industries estimated in the **V** matrix as a proxy vector.

Following the same procedure applied in the **V** matrix estimation, after these steps, we have subtracted each one of them to its respective original industry (column vector – **U** and **v**) and product (row vector – **U** and **y**).

2.1.4) Balancing the table

The new estimated industries (production recipe and output sales vector) insertion into the matrix likely generates an unbalanced table. Therefore, a numerical approach similar to Malik et al. (2014) was applied in order to retain the table consistent to the Equations 5 and 6. The idea is to scale up the production recipe column vector, keeping not only its structure, as it was applied in Malik et al. (2014), but also the estimated **V** matrix, according to

$$U_{pi} \rightarrow U_{pi}\frac{x_i}{z_i} \text{ and } v_{mi} \rightarrow v_{mi}\frac{x_i}{z_i} \qquad (7)$$

Analytical procedures were also applied, achieving then a balanced daughter table. The only missing step for completing its construction is to estimate the margins and taxes matrices, which methodology is further described.

2.1.5) Margins and taxes

Before estimating margins and taxes matrices of the daughter table, we had to alter the trade and transport margins representation with one suitable for our CGE model.

Thus, after modifying the way of representing these vectors in the table, we have implemented a simple methodology to estimate these margins and also tax matrices.

The idea is to apply concordance matrices for replicating the mother margins and taxes matrices into the expanded dimension of the daughter table. After that, we have implemented pro-rate functions and analytical procedures for "spreading" the sum of taxes and margins of each industry previous estimated into the matrix columns.

2.2) Estimating the 91 industries IOT

The procedures for estimating the industry-by-industry IOT ($C_{91,91}$) are summarized by the following equations

$$B_{126,91} = U(\widehat{z_i})^{-1} \quad (8)$$

$$D_{91,126} = V(\widehat{z_p})^{-1} \quad (9)$$

$$y_{91,6} = Dy_{126,6} \quad (10)$$

$$C = (I_{91,91} - DB)^{-1} y_{91,6} \quad (11)$$

This set of equations is based in the "Industry-related assumption" - the standard way of representing the IO model - well covered by the most IO basic literature, as Eurostat (2008) and Miller and Blair (2009).

The margins and taxes matrices estimation were based on concordance matrices from the daughter dimension to this more aggregated version, with 49 industries.

Hereafter we are ready for the next stage, the hybridization step, which the granddaughter table is the output.

2.3) "Granddaughter" table's estimation

Both the aggregation and the rearrangement that we have employed for building the granddaughter table structure can be verified in the Figure 4. In terms of aggregation, we kept the table as most disaggregated as possible from the desirable assessed industries perspective. The hybridization step is challengeable, since we have to access physical data and to link them with industries that our table is structured.

The hybridization process summarized here was based on the work done to develop the IMACLIM-S BR model (Lefevre, 2012, Wills and Lefevre, 2012, Wills, 2013), which developed a hybrid IOT with 19 industries.

A decision of how many industries to appraise is definitely a decision that has to be based on the physical data availability and all the kind of aggregation issues that aggregation procedures concern – most of them occur when industries with different products in terms of physical units are put together.

The rearrangement is easily verified in Figure 4. We have separated all of them by different segments: “Energetic”, “Agroindustry”, “Industry and ‘Gas, water, sewerage and drainage services’”, “Transport” and “Services”. This new industry placement is to facilitate the classification of industries and the computation of physical data, as each type usually follows the same kind of unit. Table 2 shows the type of unit used to represent each physical flow of one specific industry and the sources accessed for extracting these data. In the “energetic” block, we have used kilotonne of oil equivalent (Ktoe), while industries blocks from “Agroindustry” and “Industry” we have represented by tonne (t). We have typified Freight and passenger transports by t times kilometer (t.km) and passenger (pass) times km, respectively.

The physical good flows must be spread into the granddaughter table. The idea is to compute this flow into the output vector (row vector). Depending on the way that the original values are available in the sources cited by the Table 2, the level of pro-rate functions applied can vary considerable.

For example, the non-energy industries detail level in the Brazilian Energy Balance (MME, 2006) is smaller than the one provided by our granddaughter table, requiring the application of pro-rate functions (or other procedure with the same aim) to spread the values into a higher number of industries that demand the products. However, comparing with industries that the values of physical flows were acquired only in total output - as the case of lime, for example – the level of pro-rate functions requirement is smaller. The output vector, in this case, has to be entirely estimated.

The last column of Table 2 is composed by the basic price sources of each hybridized industry. The reason for going into this more laborious process of hybridization is due to attend our CGE model requirement, which seeks to obtain the most reliable value as possible. To this end, we have multiplied the basic price with the amount of physical flow computed. When the outcome of this operation is higher than the one obtained before this step, we assume that the remaining value is related to some services that were aggregated to the initial estimation. Thus, we have removed and added this value to “other service sectors”.

The basic prices that we haven`t acquired by any kind of sources - as described in the Table 2- we have estimated according to this equation: $\boldsymbol{p_{ij}} = \boldsymbol{c_{ij}}/\boldsymbol{q_{ij}}$. Then, we have used the estimated $\boldsymbol{c_{ij}}$ divided by the physical flow of the product ($\boldsymbol{q_{ij}}$) to obtain the basic price ($\boldsymbol{p_{ij}}$). For these industries, obviously, no "remaining" values were estimated (removed from its original industries and allocated to "other service sectors").

The last procedure to be mentioned is regarding the specific margin estimation. We have considered price differentiation to natural gas and electricity products, which outcomes in specific margins for the couple of industries that produce these goods. The idea behind this modeling is that the natural gas and electricity are sold to transformation industries for a lower price compared to the other economic agents – see Figure 3.

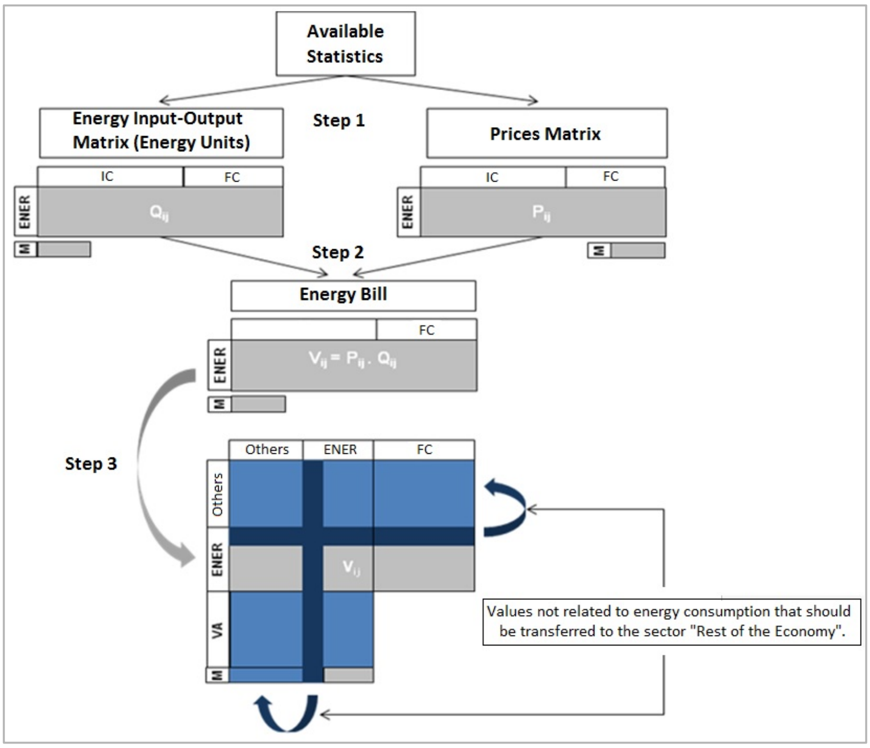

Figure 3 - Hybridization methodology proposed by IMACLIM

The tables are estimated and the next stage of this work is about the results. Then, we are going to compare the tables in order to assess our - already described - estimation procedures.

To this end, we have compared all of them in terms of Gross Domestic Product (GDP) and the original amount of physical data obtained from the sources exposed in the Table 1 and 2. We also compared the **L** values between the mother and the remaining estimated tables. They must match with the mother table.

Table 2 - Industries and its respective units, quantities and price sources

Position / Industry	Unit	Source: - quantity	 - basic price
1 / Charcoal (forestry and silviculture)	Ktoe	(a)	(b), (c) and (d)
2 / Firewood (forestry and silviculture)	Ktoe	(a)	(a) and (c)
3 / Mineral coal	Ktoe	(a)	(a), (b), (e) and (f)
4 / Crude oil	Ktoe	(a)	(a), (g) and (h)
5 / Natural Gas	Ktoe	(a)	(b)
6 / Alcohol	Ktoe	(a)	(a), (b) and (i)
7 / Biodiesel	Ktoe	(a)	(b)
8 / Gasohol	Ktoe	(a)	(b) and (g)
9 / Diesel B	Ktoe	(a)	(g)
10 / Petroleum refining and coke products	Ktoe	(a)	(b) and (g)
11 / Electricity	Ktoe	(a)	(a)
13 / Sugar cane	t	(j)	(l)
14 / Soy grain	t	(j)	(m)
23 / Sugar	t	(n)	Estimated
24 / Soy oil	t	(n)	Estimated
21 / Mining and Pelletizing	t	(n)	Estimated
23 / Cellulose and paper products	t	(n)	Estimated
25 / Steel	t	(n)	(o)
26 / Non-ferrous metals	t	(n)	Estimated
27 / Cement	t	(n)	Estimated
28 / Ceramic	t	(n)	Estimated
29 / Glass	t	(n)	Estimated
30 / Lime	t	(n)	Estimated
33 / Fertilizers and Pesticides	t	(n)	Estimated
37 / Freight transport: car and truck	t.km	(p) and (q)	Estimated
38 / Freight transport: train	t.km	(p) and (q)	Estimated
39 / Freight transport: airplane	t.km	(p) and (q)	Estimated
40 / Freight transport: ship	t.km	(p) and (q)	Estimated
41 / Passenger transport: car and truck	pass.km	(p) and (q)	Estimated
42 / Passenger transport: train	pass.km	(p) and (q)	Estimated
43 / Passenger transport: airplane	pass.km	(p) and (q)	Estimated
44 / Passenger transport: ship	pass.km	(p) and (q)	Estimated

(a) MME (2006),
(b) ANP (2014),
(c) Uhlig (2008),
(d) Imana (2014),
(e) Junior and Zancan (2006),
(f) AliceWeb,
(g) Petrobras (2014),
(h) Afonso and Castro (2011),
(i) Lima (2011),
(j) IBGE/PAM (2005),
(l) Agrianual (2010),
(m) Cunha (2014),
(n) SIDRA (2014),
(o) Instituto Aço Brasil (2007),
(p) IBGE (2005)
(q) Alves (2010)

3) Results

Table 3 summarizes the results of the tables estimation. We have focused on the GDP measurement outcomes; total labour force and the consistency between the physical amount of total output products original data and the output of them in the granddaughter table.

Table 3 - Comparisons between the tables: GDP and physical amount of products

Item to be compared		Mother	Daughter	Δ*	$IO_{91,91}$ Daughter	Δ*	Granddaughter	Δ*
GDP	10^6 R$	1,842,253	1,842,253	0.00000	1,842,253	0.00000	1,851,371	0.00495
Charcoal (forestry and silviculture)	10^3 toe	6,449	-	-	-	-	6,449	0.00004
Firewood (forestry and silviculture)	10^3 toe	34,739	-	-	-	-	34,739	0.00001
Mineral coal (t)	10^3 toe	13,814	-	-	-	-	13,814	0.00000
Crude oil	10^3 toe	101,836	-	-	-	-	101,836	0.00000
Natural Gas	10^3 toe	22,539	-	-	-	-	22,539	0.00000
Alcohol	10^3 toe	8,387	-	-	-	-	8,387	0.00000
Biodiesel	10^3 toe	644	-	-	-	-	644	0.00000
Gasohol	10^3 toe	20,058	-	-	-	-	20,058	0.00000
Diesel B	10^3 toe	35,175	-	-	-	-	35,175	0.00000
Petroleum refining and coke products	10^3 toe	134,432	-	-	-	-	134,432	0.00000
Electricity	10^3 toe	37,986	-	-	-	-	37,986	0.00000
Sugar cane (t)	t	422,956,646	-	-	-	-	422,956,646	0.00000
Soy grain (t)	t	51,182,074	-	-	-	-	51,182,074	0.00000
Sugar (t)	t	32,526,373	-	-	-	-	32,526,373	0.00000
Soy oil (t)	t	24,718,118	-	-	-	-	24,718,118	0.00000
Mining and Pelletizing (t)	t	471,240,657	-	-	-	-	471,240,657	0.00000
Paper and cellulose (t)	t	18,724,000	-	-	-	-	18,724,000	0.00000
Steel (t)	t	33,010,900	-	-	-	-	33,010,900	0.00000
Non-ferrous metals (t)	t	4,950,000	-	-	-	-	4,950,000	0.00000
Cement (t)	t	38,797,496	-	-	-	-	38,797,496	0.00000
Ceramic (t)	t	135,720,000	-	-	-	-	135,720,000	0.00000
Glass (t)	t	1,178,000	-	-	-	-	1,178,000	0.00000
Lime (t)	t	5,439,122	-	-	-	-	5,439,122	0.00000
Fertilizers and pesticides (t)	t	21,369,735	-	-	-	-	21,369,735	0.00000
Freight transport: car and truck (ton.km)	10^6 t.km	523,213	-	-	-	-	523,213	0.00000
Freight transport: train (ton.km)	10^6 t.km	222,683	-	-	-	-	222,683	0.00000
Freight transport: Airplane (ton.km)	10^6 t.km	1,787	-	-	-	-	1,787	0.00000
Freight transport: Ship (ton.km)	10^6 t.km	143,379	-	-	-	-	143,379	0.00000
Passenger transport: car and truck (pass.km)	10^6 pass.km	1,110,425	-	-	-	-	1,110,425	0.00000
Passenger transport: train (pass.km)	10^6 pass.km	17,671	-	-	-	-	17,671	0.00000
Passenger transport: Airplane (pass.km)	10^6 pass.km	61,027	-	-	-	-	61,027	0.00000
Passenger transport: Ship (pass.km)	10^6 pass.km	695	-	-	-	-	695	0.00000
L (labour - sattelite account)	workers	90,905,673	90,907,433	0.00002	90,907,433	0.00002	90,907,433	0.00002

* $\Delta = (x_i^k - x_i^m)/x_i^m$,

Where:

x_i "item to be compared", with i = 1, 2, ..., 34;
k = Daughter Table, $IO_{91,91}$ Daughter Table and Granddaughter Table;
m = Mother Table

4) Discussion

The GDP, total physical output products and total number of labour force are perhaps the main important constraints that these tables can appraise. The consistency condition of the estimated tables with the mother one is definitely sufficient from these variables point of view. Thus, testing whether these constraints are respected or not is an important step to verify if the estimation procedures and the final tables are reliable or not.

All of the items compared in the Table 3 have matched with the mother table. Only the granddaughter GDP and the number of workers in all of the estimated tables have presented a deviation when compared to the original data. However, this deviation is marginal, considering that they appear after the second and fourth decimal houses, respectively – thus, we considered the reliability of these estimated tables positive in terms of GDP, physical output products and total number of labour force.

Assessing the estimation procedures that we have described in the methodology section, it is possible to conclude that other relevant tables constraints are respected in terms of matching with the mother table. As we have detailed in this section of the study, we sought to keep the production recipe and the

V values the same. We also have implemented a method that, after any disaggregation procedure keeps the summations of the "new" vectors matching with the original one (the aggregated vector) – both rows and columns. Therefore, total intermediate consume by industries, total value added by industries, total output vector (including intermediate consume and final demand) are the cases that are also consistent when compared with the mother table respective values.

5) Conclusion

This study details a methodology for estimating a more disaggregated Brazilian SUT and IO database for 2005. This disaggregation concerns industries and products that are relevant to measure GHG emission, since our main goal is to feed a CGE model in order to construct Brazilian climate change scenarios for the long-term period.

To this aim, all of the energy, a few of agricultural, transformation and transport services industries were not only put in a high IO detail level into our database – in terms of higher number of industries in monetary units than the original table - but also computed the physical amount of this set of goods and service flows, resulting in a suitable database to be linked with BU models in further studies.

The achieved outcomes were three new tables – daughter, $IO_{91,91}$ daughter and granddaughter table, consistent with the original one – the mother table. The daughter table is a SUT with 91 industries and 126 products, while $IO_{91,91}$ daughter and granddaughter tables are IOTs with 91 and 49 industries, respectively. The last one, granddaughter table, has also data of a set of industries in physical terms: Ktoe ("Energetic" block), t ("Agroindustry" and "Industry and 'Gas, water, sewerage and drainage services'" blocks), t.km ("Freight transport" block) and pass.km ("Passenger transport" block).

This study demonstrates that a replication of this methodology to build a similar database for the same purpose can result in a reliable database able to be used by other researchers that can also apply these procedures in a different study, seeking to assess other problems beyond the climate change issue or even to analyze another region. Considering that it is not only suitable for Brazil and the climate change cases, we reckon it can be useful to other researches that are looking for an IO literature able to synthetize the steps necessary for building such kind of database.

References

AFONSO, J. R. & CASTRO, K. P. D. 2011. Carga tributária sobre petróleo no Brasil: evidências e opções. IEPE/CdG - Instituto de Estudos de Política Econômica - Casa das Garças. Available at: http://iepecdg.com.br/uploads/artigos/111101_tributacao_petroleo_v6.pdf.

AGRIANUAL 2005. Anuário Estatístico da Agricultura Brasileira. São Paulo, Brasil: FNP Consultoria e Comércio.

AGRIANUAL 2010. Anuário Estatístico da Agricultura Brasileira. São Paulo, Brasil: FNP Consultoria e Comércio.

ALICEWEB - The System Of Analysis of Foreign Trade Information. Bureau of Foreign Trade, of the Ministry of Development, Industry and Foreign Trade. Brazil. Available at: http://aliceweb.mdic.gov.br.

ALVES, F. J. 2010. Transport Sector: Reference and Low-carbon Scenarios. Brazil Low-carbon Country Case Study. Washington DC, USA: The International Bank for Reconstruction and Development / The World Bank. Available at: http://siteresources.worldbank.org/BRAZILEXTN/Resources/Brazil_LowcarbonStudy.pdf.

ANP 2014. Agência Nacional de Petroleo, Gas Natural e Biocombustíveis (Available at: http://www.anp.gov.br/preco/).

BIODIESELBR 2010. Anuário da Indústria de Biodiesel no Brasil 2004 – 2009. Curitiba - PR: Grupo BiodieselBR.

BOHRINGER, C. 1998. The syntesis of Bottom-Up and Top-Down in energy policy modeling. Energy Economics, 20, 233-248.

BOHRINGER, C. & RUTHERFORD, T. F. 2008. Combining Bottom-Up and Top- Down. Energy Economics, 30, 574–596.

BOHRINGER, C. & RUTHERFORD, T. F. 2009. Integrated assessment of energy policies: Decomposing Top-Down and Bottom-Up. Journal of Economic Dynamics & Control, 33, 1648–1661.

CUNHA, M. P. D. 2011. Avaliação socioeconômica e ambiental de rotas de produção de biodiesel no Brasil, baseada em análise de insumo-produto. Doutorado em Planejamento de Sistemas Energéticos, Universidade Estadual de Campinas.

CUNHA, M. P. D. 2014. Apoio técnico-científico ao trabalho de modelagem IMACLIM-S do Centro Clima no que se refere à adequação da matriz insumo-produto (I/O) híbrida para uma melhor representação da realidade da agropecuária brasileira dentro do modelo.

EUROSTAT 2008. Eurostat Manual of Supply, Use and Input-Output Tables. Luxembourg: European Commission.

GHERSI, F. & HOURCADE, J.-C. 2006. Macroeconomic Consistency Issues in E3 Modeling: The Continued Fable of the Elephant and the Rabbit. The Energy Journal, 39-62.

GUILHOTO, J. J. M. & SESSO FILHO, U. 2005. Estimação da Matriz Insumo-Produto a Partir de Dados Preliminares das Contas Nacionais Economia Aplicada. , 9, 277-299.

GUILHOTO, J. J. M. & SESSO FILHO, U. A. 2010. Estimação da Matriz Insumo-Produto Utilizando Dados Preliminares das Contas Nacionais: Aplicação e Análise de Indicadores Econômicos para o Brasil em 2005. . Economia & Tecnologia UFPR/TECPAR, 23, Out./Dez. ISSN 1809-080X.

HOGAN, W. W. & MANNE, A. S. 1977. Energy-Economy Interactions: The Fable of the Elephant and the Rabbit? In: HITCH, C. J. (ed.) Modeling Energy-Economy Interactions: Five Approaches (pp. 247-277). Resources for the Future, Washington D.C., United States.

HOURCADE, J. C., JACCARD, M., BATAILLE, C. & GHERSI, A. F. 2006. Hybrid Modeling: New Answers to Old Challenges Introduction to the Special Issue of The Energy Journal. The Energy Journal, Hybrid Modeling, 1-12.

IBGE 2005. Pesquisa anual de Serviços (PAS). Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística. .

IBGE/PAM 2005. Pesquisa Agrícola Municipal (PAM). Available at: http://www.ibge.gov.br: Instituto Brasileiro de Geografia e Estatística (IBGE).

IMANA, C. R. 2014. A tributação na produção do carvão vegetal. Available at: http://www.esaf.fazenda.gov.br/premios/premios-1/i-premio-florestal-brasileiro/trabalhos-premiados/?searchterm=021p: ESAF - Escola de Administração Fazendária / Ministério da Fazenda.

INSTITUTO AÇO BRASIL 2007. Relatório de Sustentabilidade 2007. (Avalable at: http://www.acobrasil.org.br/site/portugues/instituto/quem-somos--introducao.asp).

JUNIOR, A. M. & ZANCAN, F. L. 2006. Carvão mineral Nacional. Ouro Preto: ABCM - Associação Brasileira do Carvão Mineral. Available at: http://www.carvaomineral.com.br/arquivos/carvao_mineral_nacional.pdf.

LEFEVRE, J. 2012. Building Input-Output tables in physical units and in money value to calibrate hybrid energy economy CGE models: application to the Brazilian economy. 15th Annual Conference on Global Economic Analysis, Geneva.

LENZEN, M., KANEMOTO, K., MORAN, D. & GESCHKE, A. 2012. Mapping the structure of the world economy. Environmental Science & Technology, 46, 8374–8381.

LENZEN, M., MORAN, D., KANEMOTO, K., GESCHKE, A. 2013. Building Eora: A Global Multi-regional Input-Output Database at High Country and Sector Reso lution. Economic Systems Research, 25, 20-49.

LIMA, N. C. 2011. A formação dos preços do etanol hidratado no mercado brasileiro de combustíveis. Doutorado em Administração, USP.

MALIK, A., LENZEN, M., ELY, R. N. & DIETZENBACHER, E. 2014. Simulating the impact of new industries on the economy: The case of biorefining in Australia. Ecological Economics, 107, 84-93.

MILLER, R. E. & BLAIR, P. D. 2009. Input–Output Analysis: Foundations and Extensions, Cambridge, Cambridge University Press.

MME 2006. Brazilian Energy Balance 2006—Base Year 2005. Rio de Janeiro: MME (Ministério de Minas e Energia). Available at https://ben.epe.gov.br/BEN2006_default.aspx.

NASSAR, A., HARFUCH, L., MOREIRA, M., BACHION, L., ANTONIAZZI, L. & LIMA, R. 2011. Simulating Land Use and Agriculture Expansion in Brazil: Food, Energy, Agro-industrial and Environmental Impacts. Instituto de Estudos do Comércio e Negociações Internacionais - ICONE. FAPESP Relatório Científico Final São Paulo.

NEREUS. http://www.usp.br/nereus/?fontes=dados-matrizes: Núcleo de Economia Regional e Urbana da USP.

PETROBRAS 2014. Pricing. (Available at: http://www.petrobras.com.br/en/products-and-services/price-composition/).

RAMOS, R. L. O. 2014. RE: National Account Coordinator of IBGE.

SANTOS, V. E. N. D., ELY, R. N., SZKLO, A. S. & MAGRINI, A. 2015. Chemicals, electricity and fuels from biorefineries processing Brazil´s sugar cane bagasse: production recipes and minimum selling prices. Renewable and Sustainable Energy Reviews, (Under Review).

SIDRA 2014. Sistema IBGE de recuperação eletrônica. http://www.sidra.ibge.gov.br: Instituto Brasileiro de Geografia e Estatística (IBGE).

SUE WING, I. 2004. Computable General Equilibrium Models andTheir Use in Economy-Wide Policy Analysis. Joint Program on the Science & Policy of Global Change. Massachusetts Institute of Technology.

SUE WING, I. 2008. The synthesis of Bottom-Up and Top-Down approaches to climate policy modeling: Electric power technology detail in a social accounting framework. Energy Economics, 30, 547–573.

UHLIG, A. 2008. Lenha e carvão vegetal no Brasil: balanço oferta-demanda e métodos para a estimação do consumo. Doutorado - Programa Interunidades de Pós-Graduação em Energia, USP

WILLS, W. 2013. Modelagem dos efeitos de longo prazo de políticas de mitigação de emissão de gases de efeito estufa na economia do Brasil. DSc., Universidade Federal do Rio de Janeiro.

WILLS, W. & LEFEVRE, J. 2012. The impact of a carbon tax over the Brazilian economy in 2030 - IMACLIM: the hybrid CGE model approach. . ISEE 2012 Conference - Ecological Economics and Rio+20: Challenges and Contributions for a Green Economy. Rio de Janeiro. Greening the Economy - Measuring green growth, 2012.

Appendix I

Mother table		Daughter table	
Position	**Sector**	**Position**	**Sector**
1	Agriculture and forestry	1	Forestry: charcoal
		2	Forestry: firewood
		3	Forestry: wood
		4	Silviculture: charcoal
		5	Silviculture: firewood
		6	Silviculture: wood
		7	Sugar cane
		8	Soy grain
		9	Other agriculture sectors
2	Grazing and fishing	10	Beef and other living animals
		11	Live pigs
		12	Live birds
		13	Fishing and aquaculture
3	Crude oil and natural gas	14	Crude oil
		15	Natural Gas
4	Iron ore	16	Iron ore
5	Other minerals and ores	17	Other minerals and ores
		18	Mineral coal
6	Food and beverages	19	Others foods and beverages
		20	Cattle and other meats
		21	Pork meat
		22	Chicken and other bird meat
		23	Sugar
		24	Soy oil
		25	Dairy
7	Tobacco products	26	Tobacco products
8	Textiles	27	Textiles
9	Clothing	28	Clothing
10	Leather and footwear	29	Leather and footwear
11	Wood products except furniture	30	Wood products except furniture
12	Cellulose and paper products	31	Cellulose and paper products
13	Newspapers, magazines and electronic publishing	32	Newspapers, magazines and electronic publishing
14	Petroleum refining and coke products	33	Petroleum refining and coke products
		34	Gasohol
		35	Diesel B
15	Alcohol	36	Alcohol
		37	Biodiesel — NEW
16	Chemical products	38	Chemical products
17	Resins and elastomers	39	Resins and elastomers
18	Pharmaceutical products	40	Pharmaceutical products
19	Pesticides	41	Pesticides
		42	Fertilizers
20	Soaps and detergents	43	Soaps and detergents
21	Inks, varnishes, enamels, lacquers	44	Inks, varnishes, enamels, lacquers
22	Other chemical products	45	Other chemical products
23	Rubber and plastic products	46	Rubber and plastic products
24	Cement	47	Cement
		48	Ceramic
		49	Glass
		50	Lime
25	Other non-metallic mineral products	51	Other non-metallic mineral products
26	Manufacturing of steel and steel alloys	52	Manufacturing of steel and steel alloys
27	Non-ferrous metals	53	Non-ferrous metals
28	Fabricated metal products except machines and equipment	54	Fabricated metal products except machines and equipment
29	Machines and equipment, including maintenance	55	Machines and equipment, including maintenance
30	Household appliances	56	Household appliances
31	Office equipment	57	Office equipment
32	Electric machines and materials	58	Electric machines and materials
33	Electronic and communication equipment	59	Electronic and communication equipment
34	Medical and optical equipment	60	Medical and optical equipment
35	Passenger and light utility vehicles	61	Passenger and light utility vehicles
36	Trucks and busses	62	Trucks and busses
37	Vehicle parts	63	Vehicle parts
38	Other transport equipment	64	Other transport equipment
39	Furniture and other manufacturing	65	Furniture and other manufacturing
40	Electricity, gas, water, sewerage and drainage services	66	Electricity
		67	Gas, water, sewerage and drainage services
41	Construction	68	Construction
42	Wholesale and retail trade	69	Wholesale and retail trade
43	Transport and postal services	70	Freight transport: car and truck
		71	Freight transport: train
		72	Freight transport: Airplane
		73	Freight transport: Ship
		74	Passenger transport: car and truck
		75	Passenger transport: train
		76	Passenger transport: Airplane
		77	Passenger transport: Ship
		78	Rest of transport, Storage and Postal services
44	Information services	79	Information services
45	Finance and insurance	80	Finance and insurance
46	Property services and hiring	81	Property services and hiring
47	Maintenance and repair	82	Maintenance and repair
48	Hotels and restaurants	83	Hotels and restaurants
49	Business services	84	Business services
50	Private education	85	Private education
51	Private health services	86	Private health services
52	Associative services	87	Associative services
53	Domestic services	88	Domestic services
54	Public education	89	Public education
55	Public health services	90	Public health services
56	Public administration and social security	91	Public administration and social security

Granddaughter table			
Position	**Linking to Daughter`s table**	**Sector**	**Type**
1	1 and 4	Charcoal (forestry and silviculture)	**Energetic**
2	2 and 5	Firewood (forestry and silviculture)	
3	18	Mineral coal	
4	14	Crude oil	
5	15	Natural Gas	
6	36	Alcohol	
7	37	Biodiesel	
8	34	Gasohol	
9	35	Diesel B	
10	33	Petroleum refining and coke products	
11	66	Electricity	
12	3 and 6	Wood (forestry and silviculture)	**Agroindustry**
13	7	Sugar cane	
14	8	Soy grain	
15	9	Other agriculture sectors	
16	10 and 20	Catle and other animals and meats	
17	11, 12, 13, 21 and 22	Pigs, birds, fish (living, abbatoirs and processed)	
18	23	Sugar	
19	24	Soy oil	
20	19 and 25	Others foods and beverages	
21	16 and 17	Mining and Pelletizing	**Industry & 'gas, water, sewerage and drainage services'**
22	27, 28 and 29	Textiles	
23	31	Cellulose and paper products	
24	38, 39, 40, 43, 44, 45 and 46	Chemical products	
25	52 and 54	Steel	
26	53	Non-ferrous metals	
27	47	Cement	
28	48	Ceramic	
29	49	Glass	
30	50	Lime	
31	51	Other non-metallic mineral products	
32	61, 62, 63 and 64	Transport equipment	
33	41 and 42	Fertilizers and Pesticides	
34	67	Gas, water, sewerage and drainage services	
35	68	Construction	
36	26, 30, 32, 55, 56, 57, 58, 59, 60 and 65	Other industry sectors	
37	70	Freight transport: car and truck	**Transport**
38	71	Freight transport: train	
39	72	Freight transport: Airplane	
40	73	Freight transport: Ship	
41	74	Passenger transport: car and truck	
42	75	Passenger transport: train	
43	76	Passenger transport: Airplane	
44	77	Passenger transport: Ship	
45	85 and 89	Education	**Services**
46	86 and 90	Health	
47	80	Finance and insurance	
48	81	Property services and hiring	
49	69, 78, 79, 82, 83, 84, 87, 88 and 91	Other service sectors	

Figure 4 - The dynamic of sector changes from the "mother-to-daughter" and "daughter-to-granddaughter" tables: the link between them

Appendix II

Mother table		Daugther table	
Position	**Product**	**Position**	**Product**
1	Rice in the husk	1	Rice in the husk
2	Corn in the husk	2	Corn in the husk
3	Wheat grain and other cereals	3	Wheat grain and other cereals
4	Sugar cane	4	Sugar cane
5	Soy grain	5	Soy grain
6	Other product growing	6	Other product growing
7	Manioc	7	Manioc
8	Tobacco leaves	8	Tobacco leaves
9	Cotton	9	Cotton
10	Citrus fruit	10	Citrus fruit
11	Coffee	11	Coffee
12	Forestry products	12	Charcoal (forestry and silviculture)
		13	Firewod (forestry and silviculture)
		14	Wood (forestry and silviculture)
13	Beef and other live animals	15	Beef and other live animals
14	Milk from cows and other animals	16	Milk from cows and other animals
15	Live pigs	17	Live pigs
16	Live birds	18	Live birds
17	Eggs of hens and other birds	19	Eggs of hens and other birds
18	Fishing and aquaculture	20	Fishing and aquaculture
19	Crude oil and natural gas	21	Crude oil
		22	Natural Gas
20	Iron ore	23	Iron ore
21	Coal	24	Coal
22	Non-ferrous metallic minerals	25	Non-ferrous metallic minerals
23	Non-metallic minerals	26	Non-metallic minerals
24	Abbattoirs	27	Abbattoirs
25	Pork meat	28	Pork meat
26	Chicken and other bird meat	29	Chicken and other bird meat
27	Processed fish	30	Processed fish
28	Processed fruit	31	Processed fruit
29	Oil, cakes, rind, flour and other raw soy products	32	Oil, cakes, rind, flour and other raw soy products
30	Other vegetable oils except corn oil	33	Other vegetable oils except corn oil
31	Processed soy oil	34	Processed soy oil
32	Processed milk	35	Processed milk
33	Milk products	36	Milk products
34	Rice and rice products	37	Rice and rice products
35	Wheat flour	38	Wheat flour
36	Manioc flour	39	Manioc flour
37	Corn oil manufacturing and other grain preparations	40	Corn oil manufacturing and other grain preparations
38	Refined sugar	41	Refined sugar
39	Roast and ground coffee	42	Roast and ground coffee
40	Instant coffee	43	Instant coffee
41	Other food products	44	Other food products
42	Beverages	45	Beverages
43	Tobacco products	46	Tobacco products
44	Cotton ginning	47	Cotton ginning
45	Woven fabrics	48	Woven fabrics
46	Other textile products	49	Other textile products
47	Clothing	50	Clothing
48	Leather products except footwear	51	Leather products except footwear
49	Footwear	52	Footwear
50	Wood products except furniture	53	Wood products except furniture
51	Cellulose for paper manufacturing	54	Cellulose for paper manufacturing
52	Paper, cardboard and paper products	55	Paper, cardboard and paper products
53	Newspapers, magazines, and electronic publishing	56	Newspapers, magazines, and electronic publishing
54	LPG	57	LPG
55	Automotive petrol	58	Automotive petrol
56	Gasohol	59	Gasohol
		60	Diesel B
57	Fuel oil	61	Fuel oil
58	Automotive Diesel Oil	62	Automotive Diesel Oil
59	Other refinery and coke products	63	Other refinery and coke products
60	Alcohol	64	Alcohol
		65	Biodiesel (NEW)
61	Inorganic chemicals	66	Inorganic chemicals
62	Organic chemicals	67	Organic chemicals
63	Resin and elastomer products	68	Resin and elastomer products
64	Pharmaceutic products	69	Pharmaceutic products
65	Pesticides	70	Pesticides
		71	Fertilizers
66	Soaps and detergents	72	Soaps and detergents
67	Inks, varnishes, enamels, lacquers	73	Inks, varnishes, enamels, lacquers
68	Other chemical products	74	Other chemical products
69	Rubber products	75	Rubber products
70	Plastic products	76	Plastic products
71	Cement	77	Cement
		78	Ceramic
		79	Glass
		80	Lime
72	Other non-metallic mineral products	81	Other non-metallic mineral products
73	Pig iron and iron alloys	82	Pig iron and iron alloys
74	Semi-fabricates, laminates, bar and tubes of steel	83	Semi-fabricates, laminates, bar and tubes of steel
75	Metallurgic non-ferrous metal products	84	Metallurgic non-ferrous metal products
76	Cast steel	85	Cast steel
77	Fabricated metal products except machines and equipment	86	Fabricated metal products except machines and equip
78	Machines and equipment, including maintenance	87	Machines and equipment, including maintenance
79	Household appliances	88	Household appliances
80	Office equipment	89	Office equipment
81	Electric machines and materials	90	Electric machines and materials
82	Electronic and communication equipment	91	Electronic and communication equipment
83	Medical and optical equipment	92	Medical and optical equipment
84	Passenger and light utility vejicles	93	Passenger and light utility vejicles
85	Trucks and busses	94	Trucks and busses
86	Vehicle parts	95	Vehicle parts
87	Other transport equipment	96	Other transport equipment
88	Furniture and other manufacturing	97	Furniture and other manufacturing
89	Recycled scrap	98	Recycled scrap
90	Electricity, gas, water, sewerage and drainage services	99	Electricity
		100	Gas, water, sewerage and drainage services
91	Construction	101	Construction
92	Wholesale and retail trade	102	Wholesale and retail trade
93	Freight transport	103	Freight transport: car and truck
		104	Freight transport: train
		105	Freight transport: Airplane
		106	Freight transport: Ship
94	Passenger transport	107	Passenger transport: car and truck
		108	Passenger transport: train
		109	Passenger transport: Airplane
		110	Passenger transport: Ship
95	Postal services	111	Rest of transport, Storage and Postal services
96	Information services	112	Information services
97	Finance and insurance	113	Finance and insurance
98	Property services and hiring	114	Property services and hiring
99	Imputed rent	115	Imputed rent
100	Maintenance and repair	116	Maintenance and repair
101	Hotels and restaurants	117	Hotels and restaurants
102	Business services	118	Business services
103	Private education	119	Private education
104	Private health services	120	Private health services
105	Personal services	121	Personal services
106	Services rendered by associations and interest groups	122	Services rendered by associations and interest groups
107	Household services	123	Household services
108	Public education	124	Public education
109	Public health services	125	Public health services
110	Public administration and social security	126	Public administration and social security

Figure 5 - The dynamic of product changes from "mother-to-daughter" tables: the link between them