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Brazilian tax policy as response to the international economic crisis: an assessment based on the productive structure and leading sectors

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Abstract

This paper aims to discuss the tax policy undertaken by the Brazilian government since 2008 in the face of the international economic crisis. It assesses the compatibility between the leading sectors in the productive structure of the economy, i.e. those sectors which have stronger linkages in terms of production and employment maintenance in the economy, and the particular sectors benefited by the tax policy. Input-output analysis is applied to Brazilian national accounts in order to identify the main sectors according to output and employment multipliers as well as backward and forward linkages. Results show more evidences in favour of supporting some benefited sectors, such as the automobile industry and construction, rather than others, such as white goods appliances and furniture. The importance of some other sectors not directly benefited by the policy, such as food and beverages, is also highlighted.

Keywords: Brazilian tax policy; international crisis; leading economic sectors; productive structure; input-output analysis.

JEL Code: D57; E65; L52.

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Introduction

Since the beginning of the economic crisis in 2008 the Brazilian government has adopted several policy measures to address the maintenance of the levels of domestic output and employment. One of the most immediate responses to the economic downturn was the implementation of tax incentives in order to promote under a Keynesian perspective a demand recovery and the previous trajectory of economic growth[1]. The substantial reduction of the value-added tax (VAT) on several industrialised goods was the main initiative in this regard. It has been implemented in two rounds over the last five years: in 2008/2009 as a response to the world recession, and in 2011/2012 as an attempt to face the economic turmoil related to the low domestic dynamism and the negative international conditions, especially from the euro area.

The goal of this paper is to discuss the described tax policy undertaken by the Brazilian government since 2008 by assessing the compatibility between the leading sectors in the productive structure of the economy, i.e. those sectors which have stronger linkages in terms of production and employment maintenance in the economy, and the particular sectors benefited by the tax policy. Input-output analysis is applied to Brazilian national accounts in order to identify the main sectors according to output and employment multipliers as well as backward and forward linkages.

56-sectors 2008 make and use tables for the Brazilian economy, released by the Brazilian Institute of Geography and Statistics (IBGE), are employed to estimate the input-output matrix for the year when tax policy decision in favour of some sectors has been made at the first time since the crisis had started. In order to identify the leading economic sectors of the Brazilian economy, output and employment multipliers, employment generator, Hirschman-Rasmussen backward and forward linkages as well as backward, forward and total normalised pure linkages are calculated. An additional method to make this assessment of main economic sectors consists in ordering sectors according to their power-of-pull in the economy, as showed by Luo (2009). The above indices allow for the assessment of

[1] According to IBGE (Brazilian Institute of Geography and Statistics) data on national accounts, the annual growth rate of the Gross Domestic Product (GDP) was 3.2%, 4%, 6.1% and 5.2% for 2005, 2006, 2007 and 2008. In the same period, the Gross Fixed Capital Formation (GFCF) grew by 3.6%, 9.8%, 13.9% and 13.6% and household consumption by 4.5%, 5.3%, 6.3% and 5.7%, respectively. Data available at: http://www.ibge.gov.br/home/ (Access in: June 2012).

the aforementioned VAT policy on some industrialised goods, given that it shows whether economic sectors whose goods have been favoured by the economic policy match to relatively more important sectors in the Brazilian productive structure. Results could prove useful in shaping different economic policies – for instance, tax and industrial policies – to promote growth and employment.

The paper is divided in three sections. The first section addresses the tax policy implemented in Brazil and its changes regarding the favoured sectors over the recent years. The second section presents a methodological revision of the literature on input-output matrices as well as the indices applied to the analysis. The third section discusses the main results of the paper. They show more evidences in favour of supporting some benefited sectors, such as the automobile industry and construction, rather than others, such as white goods appliances and furniture. The importance of some other sectors not directly benefited by the policy, such as food and beverages, is also highlighted. Finally, remarks on the policy effectiveness to promote economic growth and avoid increasing unemployment are made.

1. The Brazilian tax incentives in the face of the international economic crisis

Brazilian economic policy response to the international economic crisis has more rapidly come from fiscal policy decisions[2]. The reduction of the value-added tax on several industrialised goods was one of the broadest and most immediately implemented measures aiming at stimulating demand, particularly through consumption, and therefore restoring production and employment levels in the economy. The policy has been implemented in two rounds over the last five years: in 2008/2009 as a response to the world recession, and in 2011/2012 as an attempt to face the economic turmoil related to the low domestic dynamism and the negative international conditions, especially from the euro area.

[2] In comparison to other economies, particularly developed economies, the Brazilian Central Bank has been behind with the adoption of an expansionary monetary policy. It has taken a considerable time before it has started reducing interest rates. It is worth highlighting, however, that other measures aiming at restoring credit in the economy have been taken, such as the reduction of long-term interest rates on loans of the Brazilian National Development Bank (BNDES) to some sectors as well as credit supply from public banks, namely Banco do Brasil and Nossa Caixa, which offered R$ 8 billion to carmakers' finance companies in November 2008 in order to encourage vehicle financing (Resende, 2008).

The three most favoured sectors by this policy in the beginning have been the automobile, construction and white goods appliances industries. Subsequently, capital goods and furniture industries have been also included. For the automobile sector, a differentiated policy on tax reduction regarding the various types of vehicles was established in December 2008. Box 1 summarises the main changes in the VAT on different vehicles since the beginning of the crisis until the early-2010, when tax rates returned to their previous original level. It also shows VAT rates on vehicles not in conformity with the automotive regime implemented in 2011 as well as new tax reductions to be initially valid from May to August 2012.

Box 1. Changes in VAT rates on vehicles since the beginning of the crisis

Engine	Fuel	Before crisis	Dec. 2008*	Jan. 2010	Apr. 2010	Outside the new automotive regime**	May 2012 to Aug. 2012***
Passenger cars up to 1,0	Ethanol or dual-fuel	7%	0%	3%	7%	37%	0% / 30%
	Petrol	7%	0%	7%	7%	37%	0% / 30%
Passenger cars from 1,1 to 2,0	Ethanol or dual-fuel	11%	5.5%	7.5%	11%	41%	5.5% / 35.5%
	Petrol	13%	6.5%	13%	13%	43%	6.5% / 36.5%
Light commercial vehicles	Any	8%	1%	4%	4%	34%	1% / 31%

Source: Decree n. 6,687 of December 11, 2008, n. 6,809 of March 30, 2009, n. 6,890 of June 29, 2009, n. 7,017 of November 26, 2009, n. 7,660 of December 23, 2011, n. 7,716 of April 3, 2012, and n. 7,725 of May 21, 2012. See also Anfavea (2010), Galvão (2009), Valor Econômico (2009) and Prado (2012).

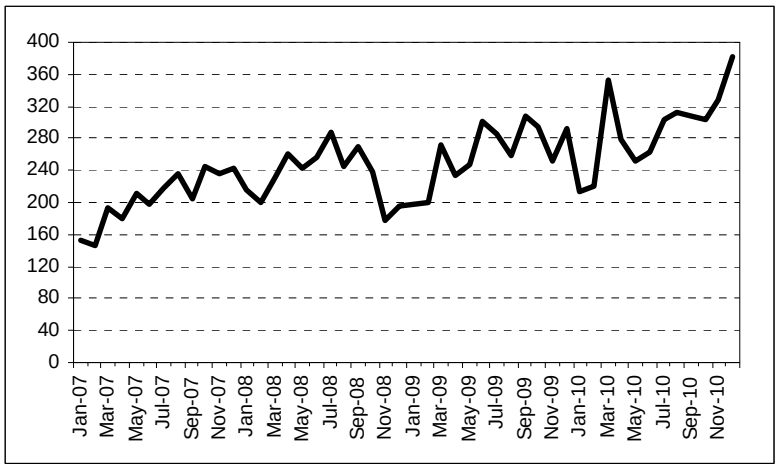
* Initially planned to stand until March 2009, these tax rates were extended until June and, then, September 2009, when it was decided that they should return gradually through monthly increases until January 2010 to their levels prior to the crisis. In the case of ethanol or dual-fuel vehicles, the tax rate returned to the previous original level in April 2010. Due to the incentive, there was a tax exemption of R$ 1.4 billion over the second semester of 2009 and of R$ 975 million in the first three months of 2010.

** In September 2011, the new automotive regime, valid from December 2011 to December 2012, was launched. According to it, carmakers should use at least 65% of national or regional content in the manufacturing of their vehicles, besides investing in research and development and making at least 6 of 11 productive stages in the country. All vehicles not in conformity with the new regulation would have a 30 percentage points increase in tax rates on them. From 2013 to 2017, new rules released on April 2012 would stand. Since then, companies should accomplish 3 of 4 prerequisites to deduct the 30 percentage points VAT increase. The rules are: to invest at least 0.15% of the gross operating income in innovation in 2013, which would increase up to 0.5% until 2017; to invest at least 0.5% of the gross operating income in engineering, which would rise up to 1% until 2017; to make 8 of 12 productive stages of light vehicles and 10 of 14 productive stages of heavy vehicles in the country, which would increase to 10 of 12 and 12 of 14 productive stages until 2017 for light and heavy vehicles, respectively; to improve the level of energy efficiency of vehicles following Brazilian patterns of energy-save, so that 25% of manufactured vehicles in 2013 should accomplish that and 100% in 2017.

*** On the left, tax rates standing on vehicles in conformity with the rules of the automotive regime. On the right, tax rates on vehicles outside the regime valid until the end of 2012. Over the period there was a tax exemption of R$ 1.2 billion.

Figure 1 shows that vehicle sales, which had been registering an upward trend over the period before the crisis, fell sharply by the end of 2008. In November of that year around 178 thousand vehicles were sold, a hundred thousand less than sales peak registered in July. Sales recovered, however, during 2009 returning in March, month initially programmed to finish the tax reduction, to the same level of September 2008. Sales rose steeply in March, June, September, and December 2009 as a response to the several quarterly-made extensions of the tax incentive duration. In March 2010, last month of the incentive to ethanol or dual-fuel vehicles, 353.7 thousand vehicles were sold. After the end of the reduced tax rate on vehicles, demand has temporarily declined. Due to the expansion of credit and economic activity[3], however, demand recovered in the second-half of the year and achieved a historic record in December 2010.

Figure 1. Vehicle sales in Brazil, 2007-2010 (thousand units)



Source: own calculations based on sales data from the Brazilian National Association of Vehicle Manufacturers (Anfavea).

Construction industry had the VAT rate on many of its goods reduced to zero from April 2009 onwards (see Box 2). The incentive has been extended for several times like in the automobile industry. The sector has also benefited from other policies, in particular the expansion of

[3] Data from the Brazilian Central Bank show that the balance of credit operations to acquire vehicles moved from R$ 157.3 billion at the end of 2009 to R$ 188.6 billion at the end of 2010, an increase of 19.9%, which is bigger than the 13% increase of the previous year. Data available at: http://www.bcb.gov.br/ (Access in: June 2012). IBGE data on quarterly national accounts point to a GDP growth of 9.3%, 8.8%, 6.9% and 5.3% in the first, second, third and fourth quarters of 2010 in relation to the respective quarters of the year before. It should be noted that the more significant results in the beginning of the year are at a large extent due to the basis of comparison, since the economic performance in 2009 only improved at the end of the year, thus making the economic recovery observed in the beginning of the following year more expressive in comparison with the one observed at the end of the year. Data available at: http://www.ibge.gov.br/home/ (Access in: June 2012).

loans from the public bank Caixa Econômica Federal to government-subsidised habitation programmes, such as the programme "Minha Casa, Minha Vida"[4].

Box 2. Changes in VAT rates on goods related to the construction industry since the beginning of the crisis

Selected construction materials	Tax rates before Apr. 2009	Tax rates from Apr. 2009 to the end of 2012 (after several extensions*)
Cement	4%	0%
Paint and varnish	5%	0%
Mortar and concrete for construction	5%	0%
Cement, mortar or concrete additives	10%	5%
Non-coated steel gratings for mortar or concrete structures or works	5%	0%
Non-refractory overlays	5%	0%
Putty	10%	2%
Painting apparel	5%	2%
Hinges	5%	0%
Baths, shower cabins, and sinks	5%	0%
Circuit breakers	15%	10%
Electric shower	5%	0%

Source: Decree n. 6,809 of March 30, 2009, n. 6,890 of June 29, 2009, n. 7,394 of December 15, 2010, and n. 7,542 of August 2, 2011. See also Salles (2009).
* Extensions made in June 2009, December 2010 and August 2011. Total tax exemption of R$ 88 million between April and mid-July 2009 and of R$ 685.8 million over the second semester of that year.

The VAT on white goods appliances was reduced in April 2009, and extended in June and once again in October of that year, when higher energy-save goods obtained a greater tax exemption. Reduced tax rates ranging between 0% and 20% according to the type of good stood until January 2010. By the end of 2011, the government adopted once more the tax reduction on goods related to this sector. The aim was to stimulate domestic activity in the face of the adverse international landscape, above all as a result of the Eurozone crisis. At this time, however, the incentive was only implemented for higher energy-efficient goods (see Box 3).

[4] This is a programme of the federal government in partnership with states and municipalities which is managed by the Ministry of Home Affairs and executed by Caixa Econômica Federal. The programme was launched in March 2009 aiming at building new habitations that could be financed by households with monthly household income up to R$ 1,600.00. After the programme extension, households with monthly income up to R$ 5,000.00 have been also included. The goal is to build 2.4 million new habitations until 2014. More details about it are available at: http://www.caixa.gov.br/ and http://www.cidades.gov.br/index.php (Access in: June 2012).

Box 3. Changes in VAT rates on white goods appliances since the beginning of the crisis

White goods appliances	Energy efficiency index	Before Apr. 2009	Apr. 2009 to Oct. 2009*	Oct. 2009 to Jan. 2010**	Dec. 2011 to Jun. 2012***
Refrigerator and freezer	A	15%	5%	5%	5%
	B	15%	5%	10%	15%
	Others	15%	5%	15%	15%
Cooker	A	5%	0%	2%	0%
	B	5%	0%	3%	4%
	Others	5%	0%	4%	4%
Washing machine	A	20%	10%	10%	10%
	B	20%	10%	15%	20%
	Others	20%	10%	20%	20%
Washboard-top load washer	A	10%	0%	0%	0%
	B	10%	0%	5%	10%
	Others	10%	0%	10%	10%

Source: Decree n. 6,825 of April 17, 2009, n. 6,890 of June 29, 2009, n. 6,996 of October 30, 2009, n. 7,660 of December 23, 2011, and n. 7,705 of March 25, 2012. See also Goy, Veríssimo and Fernandes (2009).
* With extension in June. Total tax exemption of R$ 173 million between mid-April and mid-July, and of R$ 202.8 million in the following period until October.
** Return to the original tax rates at the end of January. Total tax exemption of R$ 132.1 million during the period.
*** With extension in March. Initiative valid only for goods with Inmetro's "A" seal of energy efficiency. Total tax exemption of R$ 361 million until the end of March and of R$ 271 million for the following three additional months.

Finally, it is worthwhile mentioning that other sectors have been also favoured by similar tax exemptions[5], although they were not adopted immediately after the beginning of the crisis in 2008. The furniture industry, for example, was benefited by the VAT reduction in November 2009 with duration until March 2010 (Lima, 2009). Tax rates on wood, steel and plastic furniture as well as on pieces of wood used in furniture manufacturing were reduced to zero[6]. This specific and short-term initiative was repeated between April and June 2012 with reductions in tax rates on furniture (from 5% to 0%), PET laminated materials (from 15% to 0%), wallpaper (from 20% to 10%), and lamps and lampshades (from 15% to 5%)[7]. The sector of capital goods was also granted tax exemption on more than 70 items used in manufacturing. The measure stood from mid-2009 to the end

[5] Some measures include, for instance, the tax exemption of Social Integration Programme (PIS) and Contribution to the Financing of Social Security (COFINS) on wheat, flour and bread from mid-2009 to the end of 2010 (Galvão, 2009).
[6] Original tax rates were of 10% or 5%. See Decree n. 7,017 of November 26, 2009. Total tax exemption was of R$ 217 million.
[7] See Decree n. 7,705 of March 25, 2012. Total tax exemption of R$ 198 million for furniture and laminated materials, and of R$ 20 million for wallpapers and lamps.

of 2012 after several extensions[8]. Other sectors, however, such as textiles and footwear, despite their claims regarding their importance in the economy, have been not favoured by the same VAT reduction policy, which has mostly and for longer benefited the aforementioned industries (Cilo, 2009).

2. Theoretical framework and methodology

This section discusses first the theoretical framework based on the input-output analysis that is used subsequently to address the identification of leading economic sectors in the Brazilian productive structure in terms of output and employment. This theoretical part is followed by a discussion of methodological issues of estimating the Brazilian input-output matrix for 2008.

2.1. Theoretical framework

The theoretical framework of this study is based on the input-output analysis (Leontief, 1951). According to this approach, total output in the economy (X) can be expressed as the sum of output for intermediary consumption of different sectors (Z) and for final demand (Y). The matrix of interindustry flows (Z) and the total output allow for the calculations of the matrix of technical coefficients (A). The technical coefficient (a_{ij}) measures, in monetary terms, how much of goods the sector *j* has used from the sector *i* for its total output. In other words, it shows the proportion of inputs purchased by sector *j* from sector *i* in relation to the total output of sector *j*, as expressed in (1).

$$a_{ij} = \frac{Z_{ij}}{X_j} \tag{1}$$

It follows that:

$$X = AX + Y \tag{2}$$

The solution to this equation gives the total output necessary to meet the final demand:

[8] Initially announced to stand until December 31, 2009, the tax reduction was extended several times: until June 30, 2010 (total tax exemption of R$ 369 million), until December 31, 2010 (total tax exemption of R$ 390 million), until December 31, 2011, and until December 31, 2012. See Decree n. 6,890 of June 29, 2009, n. 7,017 of November 26, 2009, n. 7,222 of June 29, 2010, n. 7,394 of December 15, 2010, and n. 7,543 of August 2, 2011.

$$X = (I - A)^{-1} Y \qquad (3)$$

where $(I - A)^{-1} = L$ is known as the Leontief inverse or the total requirements matrix.

From the Leontief model, several impact analyses can be made in order to measure the effects of changes in demand on output, employment, value-added, among other variables. The direct coefficient (k) for each of these variables is given by the ratio between the value of the variable *K* used for generating the total output of each sector and the total output of the corresponding sector, as follows:

$$k_j = \frac{K_j}{X_j} \qquad (4)$$

From these direct coefficients expressed in a diagonal vector ($\hat{k}$) and the Leontief inverse (L) it is obtained, by sector, the total amount directly and indirectly generated of variable *K* for each monetary unit produced for final demand. This is the idea of generator, which relates the output for final demand to a given variable in the economy. Hence, the generator of a variable *K* for each sector can be calculated through the sum of each column of the matrix *GK* obtained as showed by (5).

$$GK = \hat{k} \cdot L \qquad (5)$$

The ratio between the generator of each sector and its respective direct coefficient gives the sectoral multiplier of variable *K*. The multiplier relates the direct effect of a given variable on its total (direct and indirect) effect in the economy, as equation (6) shows.

$$MK_j = GK_j / k_j \qquad (6)$$

Based on this, the output multiplier, the employment multiplier and the employment generator can be calculated[9]. For the purposes of this paper, only multipliers of type I are used. Their effects consider only the linkages between sectors as a response to interindustry

[9] Output multiplier and output generator are identical. Consequently, the output multiplier for each sector can also be obtained by the sum of each column of matrix *L*. It indicates, for each sector, the amount of production directly and indirectly generated in the economy for each unit of final demand. The bigger the multiplier of one sector in comparison to the multipliers of other sectors is, the greater its impacts on the rest of the economy will be, thus pointing to its importance to stimulate total output.

demand, i.e. they do not deal with household consumption as endogenous to the model[10].

The input-output model allows, additionally, for calculations of other indicators highlighting the linkages between sectors and the linkage power of each sector in the economy, such as Hirschman-Rasmussen backward and forward linkages as well as backward, forward and total normalised pure linkages[11]. The analysis of these indices contributes to the assessment of key sectors in the economy[12]. Whilst the term forward linkage is used to indicate the interconnection of a particular sector with sectors to which it sells its output, i.e. how much of its output is demanded by other sectors, the term backward linkage refers to the interconnection of a particular sector with those sectors from which it purchases inputs, i.e. it measures how much a sector demands from other sectors in the economy.

Considering the elements l_{ij} of matrix L and defining L^* as the average of all elements of L and L_{*j} as the sum of a column of L, the Hirschman-Rasmussen backward linkage can be calculated as:

$$BL_j = \left(L_{*j}/n\right) \Big/ L^* \tag{7}$$

For the calculation of the forward linkage index it is used the direct-output coefficients matrix (F), which consists of allocation coefficients (as opposed to technical coefficients) obtained from the matrix of interindustry flows (Z) as expressed in (8). Instead of dividing each column of Z by the total output of the sector associated with that column, each row of Z is divided by the total output of the sector associated with that row.

$$F = \hat{x}^{-1} \cdot Z \tag{8}$$

Similar to the calculation of the Leontief inverse, the Ghosh matrix or output inverse (G) can be obtained:

$$G = (I - F)^{-1} \tag{9}$$

[10] With household consumption as endogenous to the model, multipliers of type II would be obtained as they would include the income or induced effect (Miller and Blair, 2009; Guilhoto, 2009).

[11] About these indices, which are presented below, see Miller and Blair (2009), Guilhoto and Sesso Filho (2005), Guilhoto (2009), and Liu, Polenske and Guilhoto (2010).

[12] McGilvray (1977) discusses the notion of key or leading sectors in the economy, which may consider its insertion into a broader aim of economic policy in the face of the needs at each time.

Considering the elements g_{ij} of matrix G and defining G^* as the average of all elements of G and G_{i*} as the sum of a row of G, the Hirschman-Rasmussen forward linkage can be calculated as:

$$FL_i = \left(G_{i*}/n\right)/G^* \tag{10}$$

According to Miller and Blair (2009, pp.559-560), sectors could be distributed over a four-way classification depending on their backward and forward linkage results as: (a) generally independent of (or not strongly connected to) other sectors, when both linkages measure less than 1; (b) generally dependent on (or connected to) other sectors, when both linkages measure greater than 1; (c) dependent on interindustry supply, when only the backward linkage is greater than 1; and (d) dependent on interindustry demand, when only the forward linkage is greater than 1.

It is important to highlight, however, that Hirschman-Rasmussen indices do not consider the size of the sector in the economy represented by its different levels of production. Such approach is made by the GHS methodology, which results from a number of decompositions of the Leontief inverse (Guilhoto, 2009).

Considering the block matrix of technical coefficients (A), as showed in (11), composed of square matrices of direct technical coefficients of sector *j* and of the rest of the economy (A_{jj} and A_{rr}, respectively), and of rectangular matrices of direct inputs purchased by sector *j* from the rest of the economy and of direct inputs purchased by the rest of the economy from sector *j* (A_{rj} and A_{jr}, respectively), it is possible to decompose the Leontief inverse as in (12).

$$A = \begin{bmatrix} A_{jj} & A_{jr} \\ A_{rj} & A_{rr} \end{bmatrix} \tag{11}$$

$$L = (I - A)^{-1} = \begin{bmatrix} L_{jj} & L_{jr} \\ L_{rj} & L_{rr} \end{bmatrix} = \begin{bmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{bmatrix} \begin{bmatrix} \Delta_j & 0 \\ 0 & \Delta_r \end{bmatrix} \begin{bmatrix} I & A_{jr}\Delta_r \\ A_{rj}\Delta_j & I \end{bmatrix} \tag{12}$$

where

$$\Delta_j = (I - A_{jj})^{-1} \tag{13}$$

$$\Delta_r = (I - A_{rr})^{-1} \tag{14}$$

$$\Delta_{jj} = (I - \Delta_j A_{jr} \Delta_r A_{rj})^{-1} \tag{15}$$

$$\Delta_{rr} = (I - \Delta_r A_{rj} \Delta_j A_{jr})^{-1} \tag{16}$$

From (3) and (12), it follows that:

$$\begin{pmatrix} X_j \\ X_r \end{pmatrix} = \begin{pmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{pmatrix} \begin{pmatrix} \Delta_j Y_j + \Delta_j A_{jr} \Delta_r Y_r \\ \Delta_r A_{rj} \Delta_j Y_j + \Delta_r Y_r \end{pmatrix} \tag{17}$$

This process gives the pure backward and forward linkages (PBL and PFL, respectively):

$$PBL = \Delta_r A_{rj} \Delta_j Y_j \tag{18}$$

$$PFL = \Delta_j A_{jr} \Delta_r Y_r \tag{19}$$

The PBL indicates the impact of sector *j*'s total output on the rest of the economy, regardless of the input demand that sector *j* produces for its own use or requires from other sectors, and vice-versa. The PFL indicates the impact of total output of the rest of the economy on sector *j*. It is possible as well to calculate the pure total linkage (PTL) as the sum of PBL and PFL expressed in current values:

$$PTL = PBL + PFL \tag{20}$$

Dividing the pure linkages of each sector by the average value of pure linkages in the economy as a whole, one may find the normalised pure linkages in order to compare sectors given their relative size in the economy. Backward (PBLN), forward (PFLN) and total (PTLN) normalised pure linkages can be calculated as follows:

$$PBLN_i = PBL_i \Big/ \left(\sum_{i=1}^{n} PBL_i \Big/ n \right) \tag{21}$$

$$PFLN_i = PFL_i \Big/ \left(\sum_{i=1}^{n} PFL_i \Big/ n \right) \tag{22}$$

$$PTLN_i = PTL_i \Big/ \left(\sum_{i=1}^{n} PTL_i \Big/ n \right) \tag{23}$$

An additional method to identify the main sectors in the economy is suggested by Luo (2009) [13]. It stems from the notion of linking effects of sectors' production, i.e. their dependence on other supply sectors that, in turn, may be strongly dependent on another set of sectors, and so forth. It is suggested, therefore, to order sectors according to their power-of-pull in the economy. This factor *P(j)* for each sector *j* is based on the power-of-pull of the *n* sectors of the economy,

[13] In paper with similar scope of this study but looking at the American economy, Luo (2009) develops and tests a methodology to identify sectors which should be most prioritised in the face of an economic downturn, given their interconnections with other sectors and therefore the capacity of stimulating them as well.

including itself, which are directly or indirectly linked with it. This can be expressed as:

$$\lambda P(j) = x_{1j}P(1) + x_{2j}P(2) + \ldots x_{ij}P(i)\ldots + x_{nj}P(n) \qquad (24)$$

where λ is a scaling constant and x_{ij} is the dependence ratio of sector *i* on sector *j*, i.e. the proportion of *i*'s output that is pulled by *j*.

Hence, for an economy with *n* sectors, there will be *n* linear equations as (24) depending one of each other, i.e. *P(j)* with *j* = 1, 2, ..., *n*. Considering *R* as the matrix of dependence ratios and *p* as such a vector that $p = [P(1), P(2), \ldots, P(n)]'$, the system of equations can be written as:

$$R'\,p = \lambda p \qquad (25)$$

The objective is to find the solution for *p*, which corresponds to find the eigenvectors and eigenvalues for matrix R'. It is more appropriate to choose as factor of the power-of-pull to ordering sectors the eigenvector associated with the highest eigenvalue of R'.

2.2. Methodology

For the purposes of this study, 56-sectors 2008 make and use tables for the Brazilian economy, released by the Brazilian Institute of Geography and Statistics (IBGE), are employed to estimate the Brazilian input-output matrix for the year when tax policy decision in favour of some sectors has been made at the first time since the beginning of the crisis[14]. As the use table is at consumer prices, it is necessary to deduct from its values the respective margins of commerce, transport, net taxes of subsidies, imports and import taxes in order to achieve the national supply at basic prices.

In this regard, it is used the methodology of Guilhoto and Sesso Filho (2005), which provides coefficients establishing a link between the value of good *i* sold to each sector or each component of final demand *j* at market prices and the total value of good *i* sold to all sectors and components of final demand in the economy. These coefficients allow

[14] In make and use tables released by IBGE with this level of desegregation, which is the greatest available for the Brazilian economy, there is a reference to the sector of household appliances. This does not happen, however, within IBGE's more aggregate tables. It is worth mentioning as well that despite appearing the sector of household appliances it includes all types of goods and not necessarily only those benefited by the tax policy, which have been particularly white goods appliances.

for distributing over the matrix the values of aforementioned variables so that they can be deducted from consumer prices. It should be noted that values for imports and import taxes may not be allocated to exports. Their coefficients are calculated in a similar way, but only deducting exports from total demand before distributing over the matrix.

After obtaining the national supply at basic prices, it has been chosen to deal with total requirements matrix in industry-by-industry technology model, which assumes that the mix of production of a given sector may change, but its market share in goods it produces remains constant, thus resulting that the sector may change its mix of production in order to keep its market share in those markets it operates (Guilhoto, 2009). For this reason, the market share matrix (D), obtained from the make table, is multiplied by the national supply matrix at basic prices, resulting in its change from commodity-by-industry to industry-by-industry.

The next step consists in reducing the total number of sectors although maintaining a desegregation level compatible with the analysis under study. Based on aggregation proposed by Carvalho and Kupfer (2007) and considering the similarities of sectors' productive structures, the 56-sectors matrix has been converted into a 30-sectors matrix[15]. From the complete input-output matrix with 30 sectors, the matrix of technical coefficients, the Leontief inverse, output and employment multipliers, employment generator, Hirschman-Rasmussen backward and forward linkages as well as backward, forward and total normalised pure linkages and sectors' power-of-pull have been calculated. This analysis allows for the identification of the most dynamic sectors in terms of production and employment in the economy and, therefore, the assessment of the relative importance of those directly benefited sectors by the tax incentives policy to the whole economy[16].

[15] See Appendix 1 for the correspondence between the original 56-sectors matrix and the calculated 30-sectors matrix.
[16] From the theoretical framework and methodology discussed above, complementary analyses on this topic could be made aiming at comparing input-output matrices with and without the inclusion of these tax policy initiatives or calculating the effects of a positive change in final demand due to the reduced tax rates on output, employment and tax revenues.

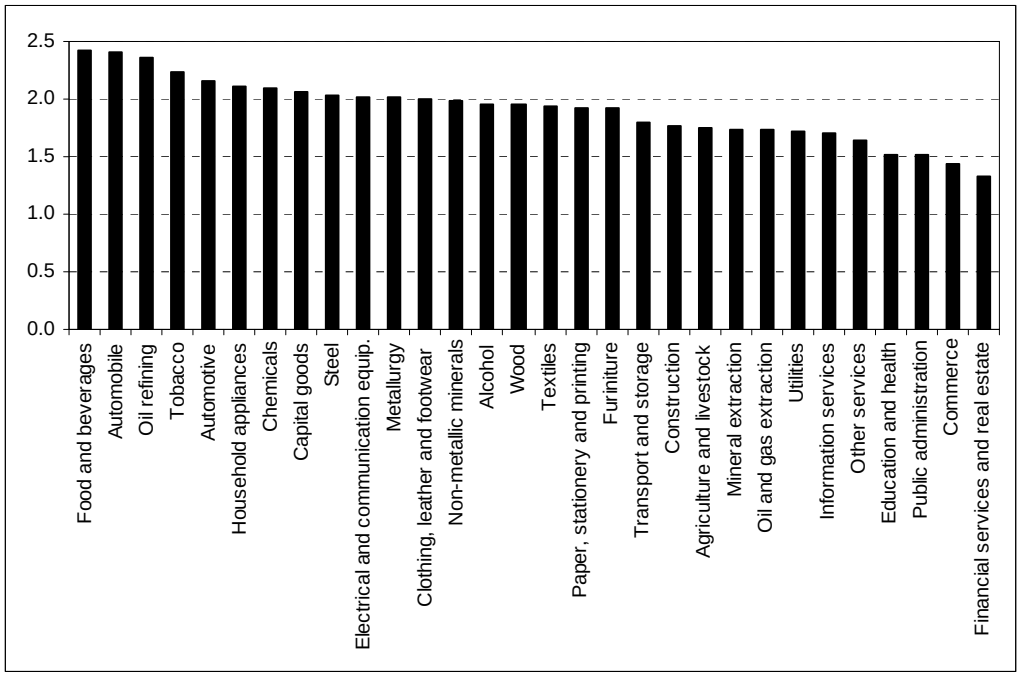
3. An assessment of leading economic sectors in the Brazilian economy and its compatibility with the tax incentives policy

This section presents the results from the input-output analysis for the Brazilian economy in 2008. Under different perspectives the relative importance of sectors to the domestic economic dynamics is assessed in order to identify those sectors that may be considered as leading or key economic sectors once their activities may impact to a greater extent the overall economic dynamics in terms of the selected variables, namely output, employment and interindustry linkages. Given the focus of the tax incentives policy on goods related to some particular sectors, which include as previously discussed the automobile industry, the construction industry and the sectors of white goods appliances, furniture and capital goods, their relative importance in the Brazilian productive structure is highlighted in the following analysis.

According to the output multiplier, the main sectors able to stimulate the total output (or production) from a given change in final demand are the industrial sectors, in particular food and beverages, automobile and oil refining industries, whose output multipliers were greater than 2.35 in the Brazilian economy in 2008. In other words, these sectors may have deep productive linkages in the economy as a whole. Under this classification, the sector of household appliances appears in the 6th position and the construction industry, in the 20th position. Capital goods and furniture industries hold the 8th and the 18th position, respectively (see Figure 2).

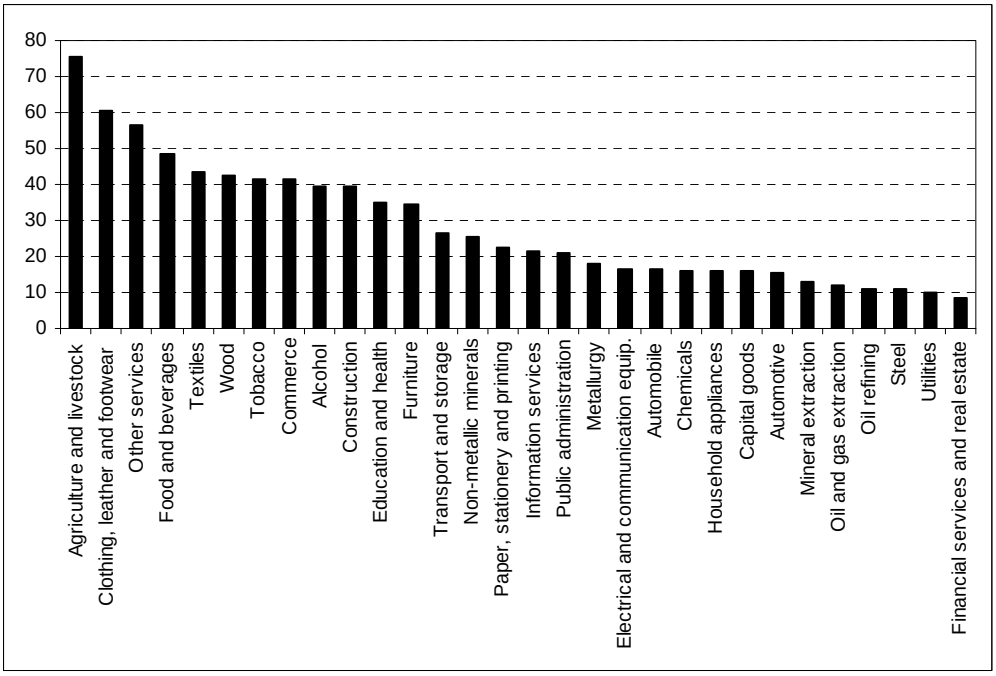
Regarding the employment generator, i.e. the amount of employment directly and indirectly generated through a variation in final demand, a greater impact may be observed in agriculture and livestock. In this sector, an additional R$ 1 million of final demand would correspond to 76 new direct and indirect jobs that would be necessary to carry out the production to meet this demand. The food and beverages industry is also important in generation of employment, holding the 4th position with an employment generator close to 50 jobs (see Figure 3).

Figure 2. Output multiplier, Brazil, 2008



Source: own calculations based on the estimated Brazilian input-output matrix for 2008. See Appendix 2.

Figure 3. Employment generator, Brazil, 2008



Source: own calculations based on the estimated Brazilian input-output matrix for 2008. See Appendix 2.

This indicator reflects partly sectors' structural characteristics. In general, capital-intensive sectors tend to appear in the lower tail of the distribution as they usually require less additional amount of labour (or workforce) to meet demand variations. On the contrary,

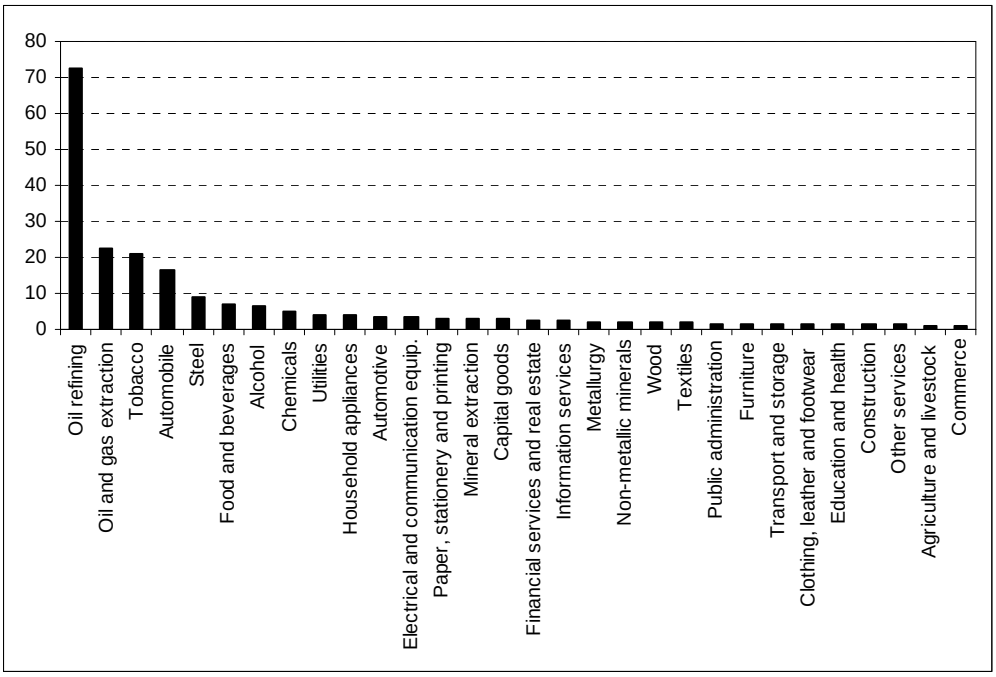
labour-intensive sectors, such as clothing and footwear, textiles, wood, tobacco and some services, present higher employment generators, since increases in final demand tend to be met by an increase in the amount of additional employment as well[17]. The furniture industry, which was later benefited by the tax incentives policy and may also be included in this category of labour-intensive sectors, did not present, however, a too high employment generator. Construction, automobile, household appliances and capital goods industries, in turn, took only the 10th, 20th, 22nd and 23rd places, respectively (see Figure 3).

The employment multiplier shows a major importance of the oil refining sector. Nonetheless, it should be noted that there is a distortion in this case due to the fact that, on the one hand, this sector employs few workers – its direct coefficient of employment is the lowest among all other sectors in the economy – and, on the other hand, it has significant productive linkages as already seen, thus resulting in a high amount of indirect employment. For these reasons, the ratio between direct and total employment showed by the employment multiplier is really expressive in comparison with other sectors[18]. According to this indicator, the automobile industry holds the 4th position, household appliances industry is at the 10th and construction, at the 27th (see Figure 4).

It is also worth highlighting that the construction industry and other sectors taking the last places of this distribution, such as other services, agriculture and livestock, commerce, clothing and footwear, and education and health, show the highest direct coefficients of employment[19], i.e. are the main sectors accounting for direct employment in the economy, given that they have the largest amount of directly employed workforce to the sectors' total output. As a result of the focus on direct generation of employment, their employment multipliers tend to be lower than in other sectors.

[17] An important remark for analysis of economic policy that is not considered by this indicator though refers to the quality of employment, which could be assessed in terms of labour conditions and average wage level for each sector.
[18] It should be noted, additionally, that demand increases for the oil refining sector may not be translated into very large generation of employment as observed from its relatively low employment generator. This is especially because of sector peculiarities, above all the fact of being a highly capital-intensive sector together with those sectors linked to it.
[19] Check the values for direct coefficients of employment in Appendix 2.

Figure 4. Employment multiplier, Brazil, 2008



Source: own calculations based on the estimated Brazilian input-output matrix for 2008. See Appendix 2.

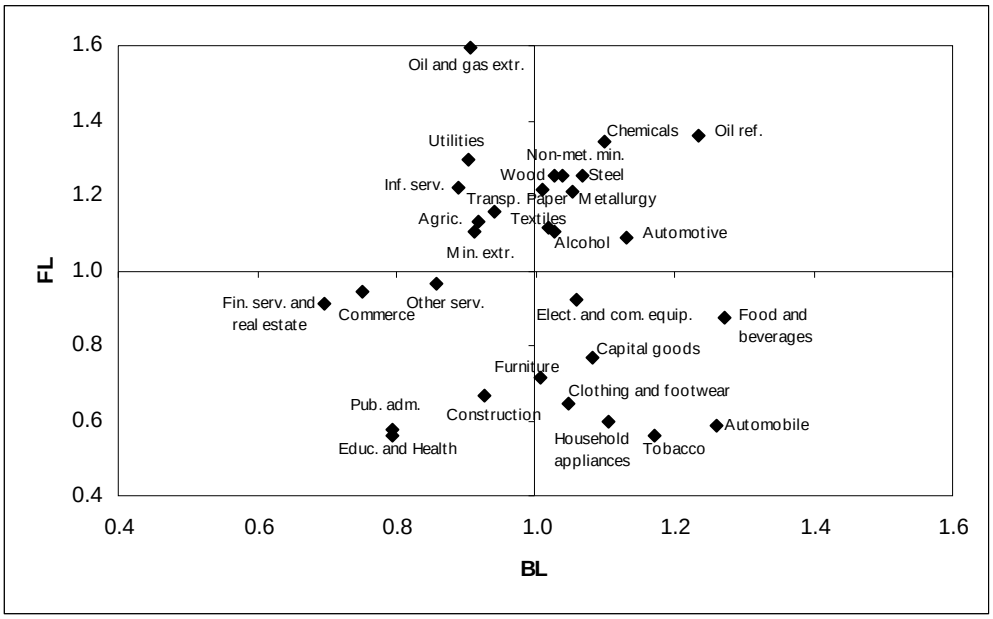
This analysis of output and employment multipliers and generators may be complemented by the degree of dependence and interconnections between sectors provided by Hirschman-Rasmussen forward and backward linkages. As previously mentioned, sectors could be classified as key sectors, dependent on interindustry supply, dependent on interindustry demand or relatively independent of others.

Figure 5 points as key sectors in the Brazilian economy in 2008 those sectors situated in the upper right quadrant, such as oil refining, chemical, automotive, steel, metallurgy, non-metallic minerals, wood, paper, textiles, and alcohol industries. Under this approach, construction industry would lie in the group of sectors generally independent of others showed at the lower left quadrant.

Among sectors strongly dependent on interindustry supply, situated in the lower right quadrant, it could be stressed both food and beverages as well as the automobile industry as presenting the highest backward linkages in the economy. This indicates their strong interconnections with other sectors on which they are dependent and, probably, a strong capacity of pulling other industries. Other sectors included in the tax incentives policy, such as household appliances and capital goods industries, are also in the

same quadrant with the 6th and the 8th highest Hirschman-Rasmussen backward linkage in the economy in 2008, respectively. Among sectors strongly dependent on interindustry demand, located at the upper left quadrant, the oil and gas extraction industry presents the highest forward linkage.

Figure 5. Hirschman-Rasmussen forward and backward linkages, Brazil, 2008



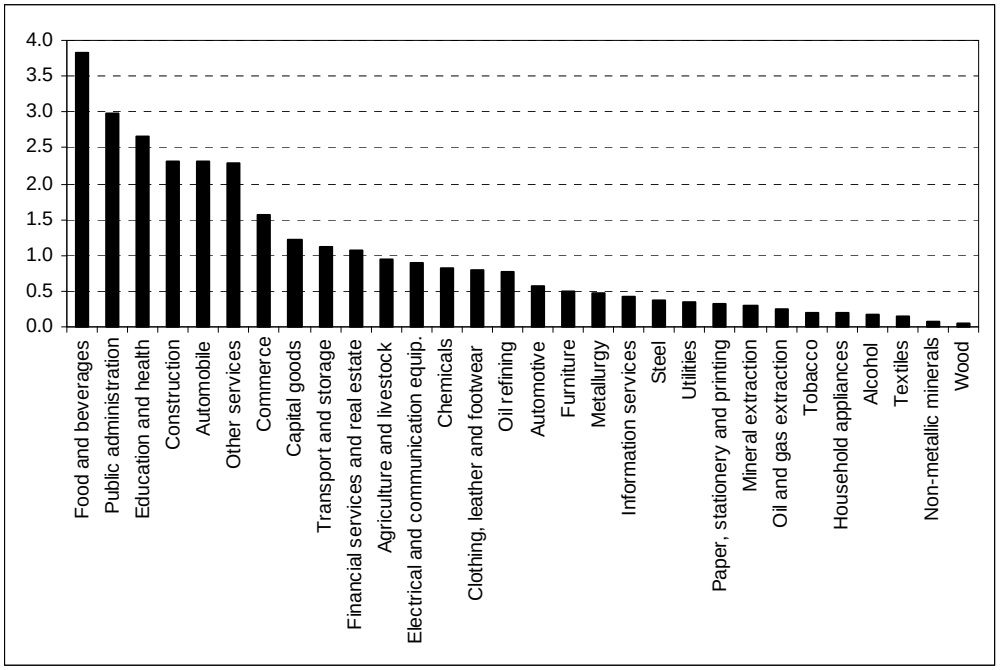
Source: own calculations based on the estimated Brazilian input-output matrix for 2008.

Nevertheless, given that these indices do not take into account the relative size of each sector in the economy as a whole, which is an important feature in the analysis of leading economic sectors, the normalised pure linkages are also calculated. Backward linkages point to food and beverages, public administration, education and health, construction and automobile industries as sectors with a greater pure impact of their production on demanding other sectors in the economy, as showed in Figure 6. The household appliances industry only appears in the 26th position, possibly due to its relatively small size in the economy.

Forward linkages, in turn, indicate those relatively more important sectors as input suppliers for the production of other sectors in the economy. Figure 7 shows the predominance of services-related sectors. As the production of those sectors favoured by the tax policy is mainly directed to final demand, they tend to register weaker forward linkages. Construction, capital goods and furniture industries hold the 18th, the 21st and the 25th position, respectively.

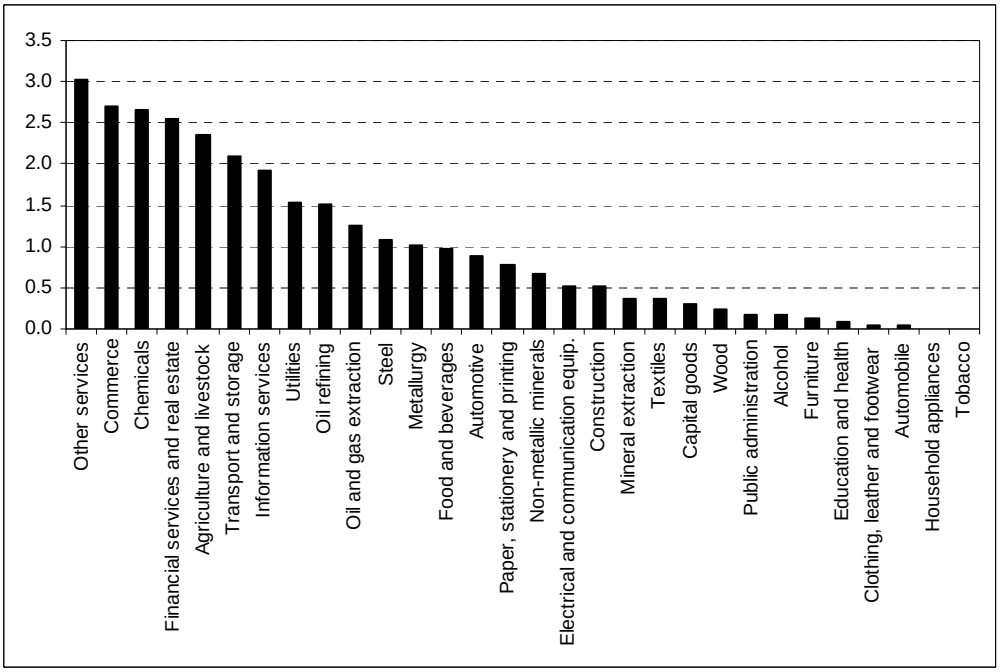
The automobile and household appliances industries are only in the antepenultimate and penultimate places.

Figure 6. Backward normalised pure linkage, Brazil, 2008



Source: own calculations based on the estimated Brazilian input-output matrix for 2008. See Appendix 3.

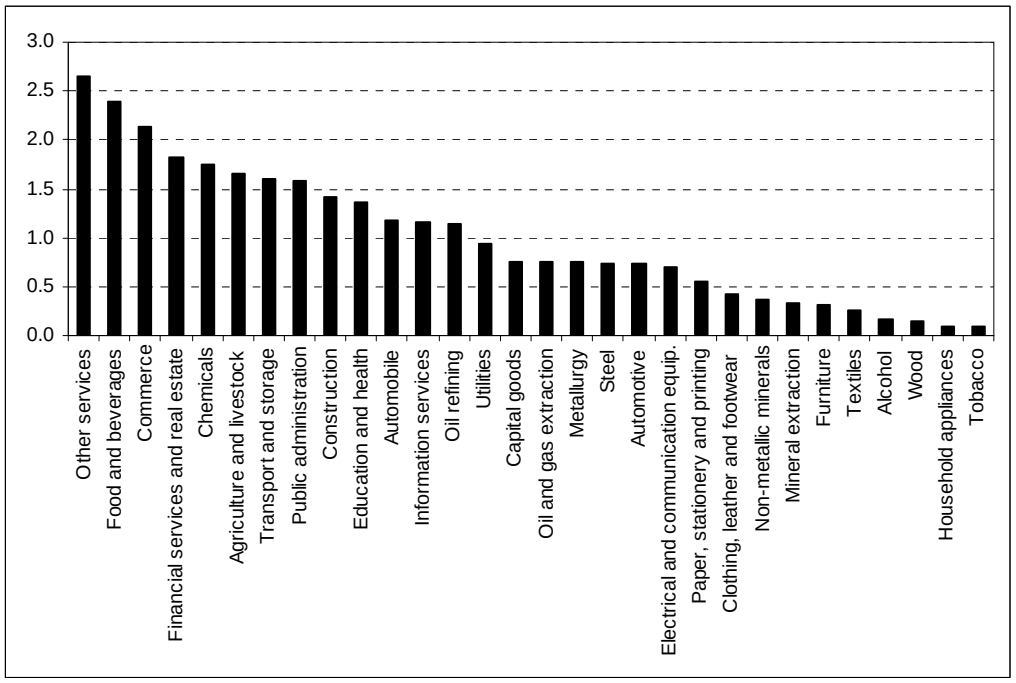
Figure 7. Forward normalised pure linkage, Brazil, 2008



Source: own calculations based on the estimated Brazilian input-output matrix for 2008. See Appendix 3.

As a result of the combination of these indices, one may obtain the total normalised pure linkage, according to which the main economic sectors considering both their forward and backward linkages would be some sorts of services labelled as other services, then followed by the food and beverages industry (see Figure 8). Under this classification, the construction industry holds the 9th position and the automobile industry, the 11th. Capital goods industry is at intermediate position (15th place). Furniture and household appliances sectors are only in the 25th and the 29th position, respectively.

Figure 8. Total normalised pure linkage, Brazil, 2008



Source: own calculations based on the estimated Brazilian input-output matrix for 2008. See Appendix 3.

An additional analysis to check the dependence between sectors across the productive chains is given by the power-of-pull. Results in table 1 point to similar conclusions of those observed in the Hirschman-Rasmussen analysis, in particular of backward linkages. The three major sectors ordered according to their power-of-pull, although in different places, are the same sectors which are strongly dependent on interindustry supply, namely the food and beverages, automobile and tobacco industries. As Luo (2009) highlights, the power-of-pull approach does not count the production volume or the size of a sector but its marginal influence on all the other sectors. Under this perspective, the governmental support for the automobile

industry (in the third position) would be more reasonable among the other benefited sectors.

Table 1. Ranking of sectors according to their power-of-pull, Brazil, 2008

Order	Sector	Power-of-pull (highest eigenvalue = 1.000)
1	Tobacco	0.560
2	Food and beverages	0.399
3	Automobile	0.344
4	Other services	0.311
5	Public administration	0.191
6	Education and health	0.181
7	Commerce	0.178
8	Chemicals	0.175
9	Transport and storage	0.173
10	Financial services and real estate	0.152
11	Agriculture and livestock	0.143
12	Automotive	0.134
13	Oil refining	0.116
14	Construction	0.110
15	Information services	0.106
16	Capital goods	0.098
17	Clothing, leather and footwear	0.095
18	Electrical and communication equipments	0.086
19	Oil and gas extraction	0.079
20	Utilities	0.078
21	Steel	0.067
22	Metallurgy	0.062
23	Paper, stationery and printing	0.048
24	Non-metallic minerals	0.030
25	Mineral extraction	0.030
26	Furniture	0.022
27	Textiles	0.021
28	Alcohol	0.013
29	Household appliances	0.012
30	Wood	0.010

Source: own calculations based on the estimated Brazilian input-output matrix for 2008.

Concluding remarks

This paper aimed to assess the compatibility between the tax incentives policy of VAT reduction on some industrialised goods undertaken by the Brazilian government since 2008 in the face of the international economic crisis and the leading economic sectors in the productive structure of the economy in terms of output and employment. Input-output analysis was applied to identify under different perspectives the main economic sectors.

Results show more evidences in favour of supporting some benefited sectors, in particular the automobile and the construction industries, rather than others, such as white goods appliances and furniture industries. The automobile industry presented, in general, a

significant importance in all different assessments, especially in output and employment multipliers, Hirschman-Rasmussen backward linkage, backward normalised pure linkage, and its power-of-pull in the economy. The capital goods industry was in an intermediate position and registered better relative performance in terms of output multiplier and backward linkages. The construction industry was particularly more relevant in backward normalised pure linkages than in other analyses. However, it is also an extremely important sector in directly generating employment.

For the household appliances sector, in which white goods appliances are included, highlights came from its output multiplier. Despite this fact, there were no clear indications of stronger interconnections with the rest of the economy. Its indices were at a large extent lower than of other industrial sectors. The furniture industry, later benefited by the tax policy, showed only intermediate positions with no special performance over the different analyses. To some extent the temporal implementation of the policy initiative covering different sectors over time is related to the importance of the sector in the economy. In this regard, the automobile industry was immediately favoured by a tax reduction on vehicles in the beginning of the crisis, followed by construction, household appliances, capital goods and furniture industries. The latter only experienced a particular and short-term tax exemption by the end of 2009 when financial conditions of companies of this sector were deteriorating.

From the analysis made in this paper, it is also worth emphasising the relevance of some sectors not directly benefited by the VAT reduction policy. The main sector in this regard was the food and beverages industry which, under several perspectives, was one of the most important sectors among industrial sectors as well as all sectors in the economy. Hence, results show strong evidences that stimulating it in the face of a crisis, for instance, would probably lead to a strong positive effect over the productive structure.

The identification of these sectors as leading economic sectors in the Brazilian productive structure could prove useful in shaping different economic policies, including tax and industrial policies, in order to promote domestic growth and employment. Obviously, the reasons to favour particular sectors with some economic policies are not limited to the analysis above. The importance of a sector in the

economy also involves political economy issues to coordinate interests of each sector.

Finally, it is important to highlight that the policy has been effective in avoiding a rise in unemployment. In fact, supportive measures to some sectors in the face of the international crisis have resulted in short-term demand recovery and employment maintenance, i.e. they have accomplished their initial objectives. However, their effectiveness has been reducing over time since their beginning in 2008. Once again adopted in 2011/2012 they have not proved so efficient as before (in 2008/2009) to stimulate economic activity, thus indicating that other types of policies are also necessary to promote a sustained economic recovery.

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Appendix 1. Map of sectoral aggregation

Origin*	Destination**
Agriculture and forestry	Agriculture and livestock
Livestock and fishing	Agriculture and livestock
Oil and gas extraction	Oil and gas extraction
Iron	Mineral extraction
Others of extractive industry	Mineral extraction
Food and beverages	Food and beverages
Tobacco	Tobacco
Textiles	Textiles
Clothing	Clothing, leather and footwear
Leather and footwear	Clothing, leather and footwear
Wood goods - excluding furniture	Wood
Cellulose and paper materials	Paper, stationery and printing
Newspapers, magazines and CDs	Paper, stationery and printing
Oil refining	Oil refining
Alcohol	Alcohol
Chemical goods	Chemicals
Resin manufacturing	Chemicals
Pharmaceutical goods	Chemicals
Pesticides and herbicides	Chemicals
Perfumery, hygiene and cleaning	Chemicals
Paint, lacquer and varnish	Chemicals
Other chemical goods and derivatives	Chemicals
Latex and plastics	Chemicals
Cement	Non-metallic minerals
Other goods of non-metallic minerals	Non-metallic minerals
Steel and derivatives	Steel
Metallurgy of non-iron metals	Metallurgy
Metal goods - excluding machinery and equipments	Metallurgy
Machinery and equipments, including maintenance and repairs	Capital goods
Household appliances	Household appliances
Office and computer equipments	Electrical and communication equipments
Electrical machinery, devices and materials	Electrical and communication equipments
Electronic material and communication equipments	Electrical and communication equipments
Medical-hospital and optical instruments/devices	Electrical and communication equipments
Passenger cars and light commercial vehicles	Automobile
Trucks and buses	Automobile
Autoparts	Automotive
Other transport equipments	Automotive
Furniture	Furniture
Production and distribution of electricity, gas, water, sewerage and urban cleaning	Utilities
Construction	Construction
Commerce	Commerce
Transport, storage and mail	Transport and storage
Information services	Information services
Financial intermediation, insurance, pension and related services	Financial services and real estate
Real estate and rent	Financial services and real estate
Maintenance and repairs	Other services
Hotels and restaurants	Other services
Services to companies	Other services
Private education	Education and health
Private health	Education and health
Services to households and associations	Other services
Domestic services	Other services
Public education	Education and health
Public health	Education and health
Public administration and social security	Public administration

Source: own classification based on Carvalho and Kupfer (2007).
* Original sector of the 56-sectors matrix.
** Corresponding sector in the 30-sectors aggregated matrix.

Appendix 2. Values of output multiplier, employment generator, employment multiplier and direct coefficient of employment, by sector, Brazil, 2008

Sectors	Output multiplier	Employment generator	Employment multiplier	Direct coefficient of employment
Public administration	1.51	21.12	1.68	12.58
Agriculture and livestock	1.75	75.62	1.23	61.27
Alcohol	1.96	39.40	6.38	6.17
Food and beverages	2.43	48.27	7.11	6.79
Automobile	2.40	16.29	16.70	0.98
Automotive	2.15	15.63	3.65	4.28
Commerce	1.43	41.53	1.22	33.96
Construction	1.76	39.26	1.38	28.43
Education and health	1.51	34.93	1.42	24.60
Household appliances	2.11	16.17	3.76	4.30
Oil and gas extraction	1.73	12.16	22.74	0.53
Mineral extraction	1.74	13.03	3.11	4.19
Tobacco	2.23	41.67	21.08	1.98
Wood	1.96	42.50	2.03	20.99
Capital goods	2.06	15.92	2.83	5.62
Electrical and communication equipments	2.02	16.58	3.65	4.54
Metallurgy	2.01	18.03	2.11	8.56
Non-metallic minerals	1.98	25.39	2.03	12.54
Furniture	1.92	34.68	1.64	21.16
Other services	1.64	56.43	1.26	44.92
Paper, stationery and printing	1.93	22.59	3.12	7.23
Chemicals	2.09	16.19	4.81	3.37
Oil refining	2.35	11.23	72.32	0.16
Information services	1.70	21.59	2.28	9.48
Financial services and real estate	1.33	8.73	2.75	3.18
Utilities	1.72	9.88	3.98	2.48
Steel	2.03	11.12	8.80	1.26
Textiles	1.94	43.27	1.80	24.00
Transport and storage	1.79	26.53	1.62	16.36
Clothing, leather and footwear	2.00	60.74	1.55	39.14

Source: own calculations based on the estimated Brazilian input-output matrix for 2008.

Appendix 3. Values of backward, forward and total normalised pure linkages, by sector, Brazil, 2008

Sectors	Backward	Forward	Total
Public administration	2.991	0.176	1.586
Agriculture and livestock	0.950	2.362	1.655
Alcohol	0.179	0.169	0.174
Food and beverages	3.822	0.970	2.399
Automobile	2.304	0.033	1.170
Automotive	0.580	0.878	0.729
Commerce	1.575	2.690	2.131
Construction	2.310	0.514	1.414
Education and health	2.656	0.081	1.371
Household appliances	0.193	0.009	0.101
Oil and gas extraction	0.258	1.255	0.755
Mineral extraction	0.302	0.376	0.339
Tobacco	0.201	0.000	0.100
Wood	0.056	0.239	0.148
Capital goods	1.223	0.298	0.761
Electrical and communication equipments	0.890	0.520	0.705
Metallurgy	0.474	1.026	0.749
Non-metallic minerals	0.080	0.665	0.372
Furniture	0.485	0.129	0.308
Other services	2.273	3.031	2.651
Paper, stationery and printing	0.319	0.771	0.545
Chemicals	0.828	2.659	1.742
Oil refining	0.774	1.523	1.148
Information services	0.415	1.922	1.167
Financial services and real estate	1.079	2.560	1.818
Utilities	0.350	1.532	0.940
Steel	0.384	1.089	0.736
Textiles	0.151	0.371	0.261
Transport and storage	1.111	2.099	1.604
Clothing, leather and footwear	0.786	0.053	0.420

Source: own calculations based on the estimated Brazilian input-output matrix for 2008.