Expected growth of sugarcane industry and impact on the Brazilian economy: 2015 and 2020

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Abstract

The sugarcane sector in Brazil has been achieving large increases in production since the beginning of the 2000s, owing to the deregulation of its two main products: sugar and ethanol. This growth has been driven more by the ethanol production, which grew at a rate of 13% per annum (between 2000 and 2009), than by sugar, which grew at an annual rate of 8% over the same period. Nevertheless, instability in the supply of ethanol is still a problem in the industry. Structural changes, such as the mechanization of sugarcane harvesting, are also in progress. Taking into account the future demands for sugar and ethanol and structural changes in projections, made by industry representatives for the years 2015 and 2020, this article employs inuput-output analysis to estimate the impact of these projections on the Brazilian economy. The results show that in 2010, with a production of R$ 66.6 billion for sugar and R$ 36.2 billion for ethanol (at 2010 prices), the total impact on the economy was about R$ 374.6 billion in Total Output (TO), R$ 210 billion in the Gross Domestic Product (GDP), R$ 62.4 billion in remuneration to employees, and a gain of 5.1 million jobs, per annum. For 2015, the estimated economic impact on TO, GDP and employee earnings was 56% higher than the values for 2010. As for 2020, the projections showed that the increases were in the range from 109 to 117% in scenario 1, or 91 to 98% in scenario 2. For job numbers, the impact in 2015 was 48% higher than that reported for 2010, while in 2020 it was between 82 to 99% higher. It was also observed that the income effect of the shocks in the ethanol and sugar sectors was the most significant part of the predicted impact on the number of jobs created in the economy. The results showed, therefore, the importance of the sugarcane industry in the economy, emphasizing the need for government policies to foster the growth of this sector.

Key words: sugarcane; ethanol; sugar; input-output matrix; Brazil.

1. Introduction

The sugarcane industry in Brazil underwent a huge change in the early 2000s, following deregulation of sugar and ethanol. Since 2000, until 2008/09, sugarcane production increased by 10% per annum. This growth was pulled more by ethanol, whose production rose by 13% per annum, than by sugar, which expanded by 8% per annum. The faster growth of ethanol production occurred because of

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the popularity of the flexfuel vehicle[3] and fiscal incentives, especially in some states, favoring ethanol fuel.

However, this growth is less than what is needed for this sector, provoking a shortage of ethanol on the Brazilian market in 2011, which caused a steady rise in fuel prices and ethanol imports. This scenario had a number of contributory causes: the reduction in investments due to the 2008 financial crisis; the increase in oil prices that raised the price of inputs for sugarcane production; the increase in the sugar price in the international market and; the off-season for sugarcane. As a result of corporate restructuring in the sector caused by the 2008 crisis and the reduction in supply of ethanol in 2011, the sector has been designing a major expansion in production for the coming years. This expansion is also projected, although with more conservative estimates, by the Ministry of Agriculture, Livestock and Supply (MAPA).

In addition, structural changes are under way in the sugarcane industry and the change from manual to mechanical harvesting is the most significant of them. This is happening because sugarcane burning has been prohibited and the deadline for its elimination brought forward in São Paulo State, which is the bigger sugarcane producer in Brazil. According to Paes (2007), the percent mechanization in the center and south of Brazil in 2006 was 35%, but, as explained by Moraes (2007), mechanization is an irreversible trend, not only because pre-harvest burning is prohibited, but because of the advances of the agricultural labor law in Brazil and the economic incentive of using sugarcane bagasse and straw in the co-generation of electricity and its sale. This last point reminds us of another change in the sector, namely the production not only of sugar and ethanol, but electricity too. In the long term, we can think the use of sugarcane bagasse and straw to produce of second-generation ethanol. However, this is not a feasible option for the next 10 years (Unica, 2011).

In this scenario of change, we sought in this study to estimate the impact that the sugarcane sector will printing on the Brazilian economy as a result of the growth expected next 10 years.

To achieve our main objective, we used the estimates made by the sector for production in 2015 and 2020 and the structural changes expected in those years. These data are described next in Section 2. Section 3 describes the analytical methodology used and Section 4 reports and analyzes the results. Final conclusions are drawn from the study in Section 5.

2. Industry Forecasts and Structural Changes

Growth estimates for the sugarcane industry made by UNICA (Sugarcane Industry Association) forecast an increase of around 64% in sugarcane processed in 2015/16, relative to 620 million tons in 2010/11. This means an annual growth rate of 10.5%. This follows from a projected increase of 15% in sugar production and 112% in ethanol production, whose growth rates are respectively 2.9% and 16.2%

[3] It is a vehicle with engine that accepts gasoline or ethanol as required.

per annum. In 2020/21, two alternative scenarios are described, with annual growth rates between 2010/11 and 2020/21, for sugarcane, sugar and ethanol respectively, of: 8.2%, 2.8% and 12.1% in scenario 1 and 6.1%, 2.6% and 8.2% in scenario 2. The production volumes expected over the next 10 years are presented in Table 1. We can see that an increasing percentage of the processed cane is predicted to go into ethanol production. While in 2010/11 this percentage was 58%, the estimate for 2015/16 is 74% and for 2020/21, about 80%.

Table 1. Production of the main sugarcane products in 2010/11 and forecast for 2015/16 and 2020/21

	2010/11	2015/16	2020/21 scenario 1	2020/21 scenario 2
sugarcane (million tons.)	620.2	1,020	1,370	1,250
sugar (million tons.)	38.1	44	50	50
ethanol (million m^3 or billion liters)	27.4	58	86	76

Source: Unica (2011).

According to UNICA (Unica, 2011), these projections are based, for sugar, on the growth rates observed in recent years in consumption and exportation. For ethanol, the growth rate of the demand for flex fuel vehicles was used assuming 50% of the fuel used by the vehicles to be ethanol. Since the international ethanol market is not consolidated yet and depends on the creation or alteration of public policies in other countries, only rough estimates were made for ethanol exports. The difference between the two scenarios in 2020/21 is that these estimated exports are included in scenario 1.

These values are close to, but not the same as, those projected by the MAPA (Brazil, 2011). According to estimates made by this Ministry for 2015/16, a production of 821.5 million tons of cane, 41.2 million tons of sugar and 44.18 million m^3 of ethanol is expected. In 2019/20, sugarcane, sugar and ethanol are expected to reach: 893 million tons; 46.7 million tons and 62.9 million m^3, respectively. Thus, the MAPA projection is more pessimistic than that of the sugarcane industry. The main difference between these two forecast is in ethanol production. While UNICA expect this to jump (in million m3) from 27.4 in 2010/11 to 58 in 2015/16 and to between 76 and 86 in 2020/21, that is an annual growth rate between 10 and 12% over the period 2010 to 2020, MAPA estimated this rate at around 8% for the same period.

However, the changes forecast for 2015/16 and 2020/21 are not restricted to the data shown in Table 1. As already mentioned, large structural changes are occurring in this sector. The most evident of these, which has begun to be implemented in the field, is the mechanization of the harvesting of sugarcane and consequently a reduction in the labor force.

Using data from PNAD, the National Household Sample Survey (IBGE, 2011b), we calculated an annual growth rate, in jobs per ton of cane between 2006 and 2009 (last year available), of -10%. However, using data from RAIS, the Annual Listing of Social Information (Brazil, 2011), which consider only the formal jobs, this growth rate was -11%. For the period between 2001 and 2010 (RAIS has data for 2010), this rate was -9%. Therefore, we have assumed that the jobs in this sector decrease at a rate of approximately -10% per ton of sugarcane.

This reduction was estimated for 2015/16 and 2020/21 and is displayed in Table 2. However, according to information from the industrial sector (Unica, 2011), complete sugarcane harvest mechanization will lead to about 500 jobs per million tons of cane. Thus, this limit was placed on the projected fall calculated from the annual rate of decrease of jobs in sugarcane production.

Table 2. Production, remuneration and employee numbers in sugarcane production for 2006, 2010 and forecast 2015 and 2020

	2006	2010/11*	2015/16*	2020/21*
Cane production (million tons)	387	620.2	815	1,380
Employees in sugarcane production	459,710	676,924	520,251	492,691
Relation: Employees/million tons	1,187	1,091	638	500
Remuneration *per capita* (Brazilian reals, p.a.)	5,216	8,119	12,065	17,646

Note: *Forecast. The forecast of production was made by UNICA. The forecasts of employees and remuneration were made by the authors.

Source: Unica (2011) and authors.

The remuneration, on the other hand, moves in the opposite direction to the employment figures. According to dada from PNAD (IBGE, 2011b), between 2006 and 2009, the remuneration *per capita* increased at an annual growth rate of the 9%. Thus, a scenario was predicted, taking into account the new jobs and remuneration for sugarcane production, in each year analyzed. The new numbers of employees per million tons produced and annual remuneration *per capita* are shown in Table 2.

3. Methodology

This study sought to analyze the impact on the Brazilian economy of the expected increase in production of the sugarcane industry. The approach adopted for this identifies the relationships among the all Brazilian sectors. The analysis is based on a matrix of technical coefficients derived from the input-output matrix of the Brazilian economy, for 2006. This matrix (A) represents the relationships of intermediate demand. The production value in the economy (matrix X) can be described as:

$$AX + Y = X \quad (1)$$

where Y is the matrix of final demand. This can be rearranged to:

$$X = (I - A)^{-1} * Y \quad (2)$$

where X represents the output of the economy and $(I - A)^{-1}$ takes direct and indirect impact into account and is described as the Leontief inverse matrix (Miller & Blair, 2009).

From this Leontief inverse matrix we obtain the type I output multipliers. These multipliers are the direct and indirect effects of the shocks. We can also find the income effects corresponding to the increase in household demand resulting from the direct and indirect effects of the increase in economic activity: type II multipliers. This last impact is obtained by closing the model in relation to the households. In this case, the Leontief inverse matrix is derived from a matrix $\overline{A}$ of technical coefficients, where the household consumption is treated as endogenous, so that the sector multipliers are calculated from the matrix $\left(I - \overline{A}\right)^{-1}$.

Thus, the total output of the economy that is driven to meet the change in final demand is obtained as follows:

$$\overline{X} = \left(I - \overline{A}\right)^{-1} \overline{Y} \quad (3)$$

where $\left(I - \overline{A}\right)^{-1}$ is the new Leontief inverse matrix.

Recapping, the impact multipliers, ie, matrices $(I - A)^{-1}$ and $\left(I - \overline{A}\right)^{-1}$, were used to calculate the impact on the Brazilian economy. To this end: (a) the input-output matrix for Brazil was estimated for 2006, following the method presented by Guilhoto and Sesso Filho (2005 and 2010); (b) the 55 sectors presented by National Accounts (IBGE, 2011a) have been expanded to 129 sectors, including information for the sectors of sugarcane, sugar and ethanol.

In this study, shock has been expressed in demand increase, as described in Table 1 for sugar and ethanol sectors. The sugarcane sector received the impact from other sectors, given by the relationship described in input-output matrix. However, the shocks should be expressed in value and not in volume, as described in that table. Thus, the prices for those products was obtained from the 2006 input-output matrix, by dividing the total values by the volumes produced in 2006. The basic prices obtained were: R$1,343[4] per ton for sugar and R$1,016 per m^3 for ethanol. Table 3 shows the values of the demand shocks for the sugar and ethanol sectors.

Another impact estimated was related to employment in the sugarcane sector. Since the employment coefficients for the years of the forecast will not remain the same (because of the increase in harvest mechanization), this coefficient was modified. Table 2 describes the structural changes assumed in this analysis. In addition, the annual costs of the mechanization of the sugarcane harvest were incorporated, by calculating: (i) the number of harvesting machines that will replace the jobs existing in

[4] R$ = Brazilian real.

2006; (ii) the basic price of this machine and (iii) the life of the machine. Table 3 describes the shocks for 2015/16 and 2020/21, including the increase in demand for harvesters.

Table 3. Values of the demand shocks applied to the input-output matrix (million Reals of 2006)

	2015/16*	2020/21* scenario 1	2020/21* scenario 2
Sugar	59,119	67,180	67,180
Ethanol	58,935	87,386	77,225
Harvesting machines[5]	1,939	2,830	2,582

Note: *Forecast. The forecast of production was done by UNICA. The forecast of demand for machines was made by authors.

Source: Unica (2011) and authors.

The impact on the economy was analyzed as effects on: Total Output (TO), Gross Domestic Product (GDP), employment numbers and remuneration. The results, except for number of employees, were transformed from 2006 prices to 2010 prices, taking the implicit deflator of GDP for the period to be 1.3.

4. Results and Discussion

Figures 1 and 2 represent the expected impact on the Brazilian economy of the shock described in Table 3 and the changes in structural coefficients described in Table 2. The impact of production in the most recent harvest (2010/11) is also presented, for comparison with the demand increase impacts forecast for the years 2015 and 2020. For 2020, two alternative scenarios are presented, as explained in Section 2. The percentage values marked over the bars in these figures show how much the total value (direct, indirect and income effect) of each indicator increased relative to the base (2010/11).

[5] For this shock, the follow information was used:

	2010/11	2011/12	2015/16	2020/21 _ scenario 1	2020/21 _ scenario 2
Jobs replaced by machines	454,896	537,560	1,221,502	1,782,969	1,626,797
Number of machines	5,686	6,720	15,269	22,287	20,335
Basic price of machine (thousand Reals)	634,95				
Value (million Reals)	3,610	4,267	9,695	14,151	12,912
Life cycle of harvester	5 years				
Shock (million Reals per annum)	722	853	1,939	2,830	2,582

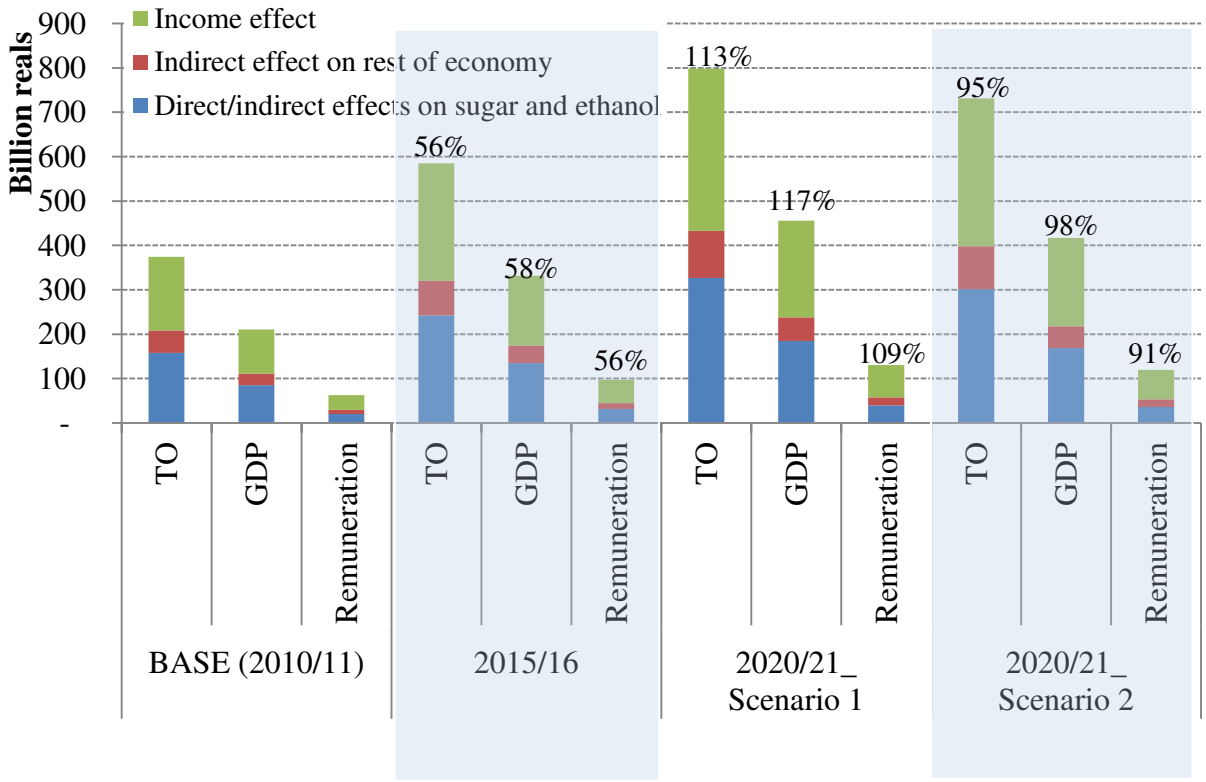

Figure 1. Direct, indirect and income effects of the shocks in sugar and ethanol demand and structural changes in the sugarcane industry for 2015 and 2020 on: Total Output (TO); GDP and remuneration in the total Brazilian economy

Sources: results of research.

The results show that the shock of R$66.6 billion in sugar production and R$36.2 billion in ethanol (2010 prices) in 2010 caused a total impact on the economy of: R$374.6 billion in Total Output (TO), R$210 billion in GDP, R$62.4 billion in total remuneration and a gain of 5.1 million jobs. However, the shock for scenario 2 in 2020 caused: R$731.6 billion in TO, R$416.7 billion in GDP, R$119.5 billion in total remuneration and 9.4 million jobs in the Brazilian economy. Overall, the impact was about 56% higher in 2015 than in 2010, for TO, GDP and remuneration. For 2020, the increase over 2010 was more than 100% in scenario 1 or between 90 and 100% in scenario 2.

However, we can see in Figure 2 that the increase in the number of jobs did not achieve the same growth rate, being somewhat slower than that observed for the variables considered in Figure 1. This occurs because of the impact of cane harvest mechanization. This growth rate was about 10 percentage points lower than that seen in Figure 1. However, even assuming complete mechanization of the cane harvest, we observe that there is increase in the total number of jobs in the Brazilian economy, arising from the growth of the sugarcane industry.

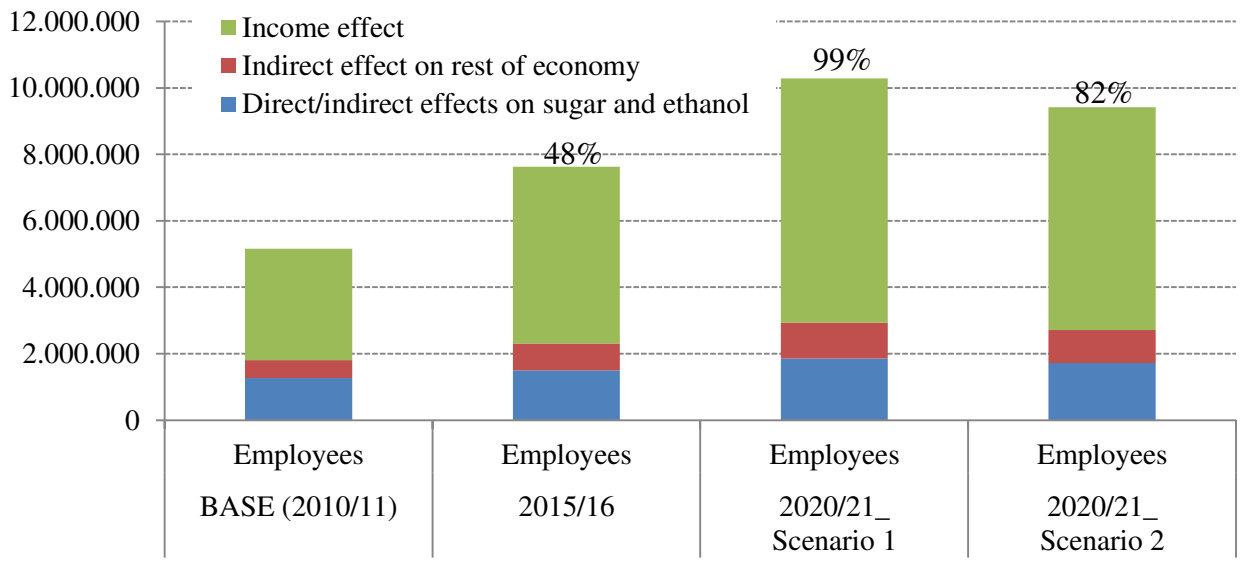

Figure 2. Direct, indirect and income effects resulting from the shocks in sugar and ethanol demand and structural changes in the sugarcane industry for 2015 and 2020 on: total numbers of jobs in the Brazilian economy

Sources: results of research.

The income effect had a more important impact on the creation of jobs in the Brazilian economy (Figure 2) than on the other variables analyzed in Figure 1. The income effect was responsible for 71% of the total new jobs, 56% of the increase in remuneration and 46% of the increase in TO and GDP. This shows the importance of the income effect in the assessment of impact and that the final products demanded by families produce a higher impact on jobs than does the production of the sugarcane industry. In other words, the sugarcane industry generates income stimulating the consumption of families and on increase in the demand on sectors that generate more jobs.

However, the impact on employee numbers within the sector was not the same. The direct and indirect employees who remained in the sugarcane industry were 635 thousand in 2010, 546 thousand in 2015 and 407 thousand in 2020 (scenario 1) or 379 thousand (scenario 2). Thus, the increase in sugarcane production is not sufficient to reduce the number of jobs that migrate to other sectors of the economy. This result can be seen as positive, since this migration is from a less qualified job to a better qualified or better paid job. However, this reduces the absorption of skilled workers by the labor market. Therefore, this result emphasizes the need for the government and sugarcane employers to be concerned about the qualifications of the cane harvesters, and this is apparently happing.

We also emphasize the importance of the sector in the Brazilian economy. Considering the Brazilian GDP in 2010 (about R$3,674 billion), the total value (direct and indirect effect and income effect) estimated to be affected by the sugarcane industry (R$210 billion) was 5.7% of this GDP.

Analyzing by sector, sugarcane production was found to be the sector most affected by the increase in sugar and ethanol demand. This sector is predicted to raise its production by 1,082 million tons in 2015. Considering the current productivity (about 80 tons per hectare), about 6 million hectares should be demanded. For 2020, in scenario 1, the increase in production was of 1,601 million tons and in scenario 2, 1,416 million tons. The necessary increase in area should be 12 and 13 million hectares, respectively, from 2010 to 2020, to achieve these quantities (for the same productivity as in 2010). This result is equivalent to doubling the current area planted with sugarcane (about 10 million hectares), or to expanding sugarcane by 7% of the current pasture area in Brazil, in the next 10 years.

The main sectors of the Brazilian economy impacted by these shocks, considering the Total Output (TO), number of employee, GDP and remuneration, are described in Table 4. As expected, the sectors with the largest impacts were those in which the shocks occurred: sugar (sector 19) and ethanol (sector 32). The next most affected sector is sugarcane (sector 2), because it is the leading provider of input to the sugar and ethanol sectors. These sectors appear bold in Table 4. When the total impact (direct, indirect and income effect) is considered (right of table), most the loss of position of the ethanol sector is noteworthy in employment. In this case, this sector fell to the 10^{th} position among the most impacted sectors.

Consequently, considering only the direct and indirect impacts on TO, the five sectors most affected by the shock in sugar and ethanol production, besides those that were shocked and the sugarcane sector, were: petroleum refining, financial intermediation, fertilizers, road freight and pesticides. Considering the same impacts on the number of jobs, the five most affected sectors (besides the three mentioned before) were: other agriculture, forestry and logging; other business services; cattle; road transport and; other wholesalers. When GDP or remuneration were the variables analyzed, the five sectors most affected were the same as those described for TO, but in a different order.

However, when we take the income effect into consideration, the results are a little different from those presented above, where only direct and indirect effects were considered (Table 4). This is expected, given the importance of the income effects, as observed in Figure 1 and, especially, in Figure 2. Thus, on one hand, these sectors gain in importance: other real estate services and rent; other retail trade; home services; food services and commercial education. On the other hand, other sectors lose relative importance: fertilizer; pesticides; wholesale diesel. These results exhibit important characteristics for the assessment of incentives to the Brazilian sugarcane industry. The next section discusses those characteristics and makes policy suggestions.

Table 4. Sectors most affected by shocks in sugar and ethanol demand, considering various impacts and the variables: Total Output (TO), employment, GDP and remuneration

Rank	Direct and indirect impact				Direct, indirect and income impact			
	TO	Employment	GDP	Remuneration	TO	Employment	GDP	Remuneration
1st	**19**	**2**	**19**	**19**	**19**	**2**	**19**	**19**
2nd	**2**	**19**	**2**	**2**	**2**	1	**2**	**2**
3rd	**32**	1	**32**	**32**	**32**	**19**	**32**	109
4th	31	**32**	109	109	109	90	112	**32**
5th	109	117	83	117	112	125	109	117
6th	34	3	117	83	31	117	117	125
7th	91	91	91	80	117	3	1	90
8th	39	83	1	1	1	115	90	118
9th	117	50	34	79	90	124	74	1
10th	83	96	31	91	74	**32**	83	119
11th	50	109	50	50	91	25	115	83
12th	8	108	8	34	115	113	119	124
13th	1	84	80	96	119	89	91	3

Note: Identity of the sectors indicated by number: 1 - other agriculture, forestry and logging; 2 – sugar cane; 3 – cattle; 8 – oil and others; 19 – manufacture of sugar; 25 – clothing and accessories; 31 – petroleum refining; 32 – ethanol; 34 – fertilizer; 39 – pesticides; 50 – metal products, except machinery and equipment; 74 – distribution of electricity; 79 – wholesale gasoline C; 80 – wholesale diesel; 83 – other wholesalers; 84 – retail gasoline C; 89 – supermarkets; 90 – other retail trade; 91 – road freight; 96 – activities auxiliary transport; 108 – activities of computers; 109 – financial intermediation and insurance; 112 – other real estate services and rent; 113 – maintenance and repair; 115 – food services; 117 – other business services; 118 – commercial education; 119 – health mercantile; 124 – other services to families; 125 – home services.

Source: research.

5. Conclusion

This study attempts to combine the predictions made by the representatives of the sugarcane industry (UNICA) for the sugar and ethanol sectors with their potential effects on the Brazilian economy. For this purpose, the potential impacts on the Total Output (TO), Gross Domestic Product (GDP), number of jobs and the value of remuneration in the whole economy were estimated. The input-output matrix was

used and the shocks estimated were a forecast of production by the industry and structural changes in the employment coefficient that will occur with the mechanical harvesting of sugarcane.

We conclude that: (i) the shocks multiplied the indirect and income effects on TO by four; (ii) the shocks more than doubled the impact on GDP in the Brazilian economy; (iii) for each job created in the sugar and ethanol sectors, more than 10 jobs were generated in the whole economy, and (iv) every R$ 1 million increase in real wages in the sugar and ethanol sectors generated more than R$ 5 million salary in the economy as a whole.

This favorable outlook for the Brazilian economy, driven by demand for products of the sugarcane industry, show us how a beneficial impact can be generated by encouraging demand for such products. Moreover, even though problems may arise from instability in the supply of ethanol, due either to the sugarcane off-season or to rising international sugar prices and production switching from ethanol to sugar, the industry as a whole has great relevance on the national scene. In this connection, it is worth noting the growth of this sector in Brazil after the deregulation process in the early 2000s: the volume of sugarcane crushed in the country had an annual growth rate of 9% from 2000 to 2010 (Brazil, 2011), while the previous period had a growth rate of 1% per annum (between 1985 and 2000). This growth rate observed in recent years is comparable to the growth observed in 1975-1985, when the "Proálcool" program was implemented by the Brazilian government and crushed sugarcane grew at 13% per annum.

Therefore, the main policies for the sugarcane industry that would benefit the whole Brazilian economy are: (i) not to reimpose price regulation that occurred in the period before 2000, giving freedom for the sector to grow; (ii) to offer incentives for investments in the sector; (iii) to work with the World Trade Organization (WTO) against protectionist policies elsewhere that limit Brazilian sugar and ethanol exports.

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